Psychosoziale Faktoren von Übergewicht und Adipositas in der digitalen Adipositastherapie

Psychosocial Factors of Overweight and Obesity in Digital Obesity Treatment

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“Starts with hard work, ends with champagne.”

Michael Jordan

Zusammenfassung

Die Prävalenz von Übergewicht und Adipositas hat sich in den vergangenen fünf Jahrzehnten nahezu verdreifacht, mit erheblichen Kosten für die Gesundheitssysteme weltweit. Es bedarf der Entwicklung effektiver und effizienter Therapien zur Gewichtsreduktion. Dabei könnten digitale Interventionen eine kostengünstige Alternative zu analogen Angeboten darstellen, die mithilfe von Tailoring-Elementen individuell auf die NutzerInnen zugeschnitten werden können. Mobile (mHealth) Interventionen sind gut in den Alltag Betroffener implementierbar. Studien zeigen, dass Betroffene mithilfe von mHealth Lebensstilinterventionen kurzfristig erfolgreich Gewicht reduzieren können. Die Kombination mit analogen psychotherapeutischen Angeboten scheint die Effektivität zu erhöhen, jedoch sind diese ressourcenintensiv. Die Implementierung psychologischer Elemente in die digitale Adipositastherapie könnte zu einer Verbesserung der Effektivität bisheriger mHealth Interventionen beitragen. Aus dem Biopsychosozialen Modell von Übergewicht und Adipositas kann abgeleitet werden, dass die Bearbeitung psychosozialer Faktoren zu einer Verbesserung von dysfunktionalem Essverhalten führen und damit zu einer Gewichtsreduktion beitragen kann. Dabei zeigen sich Geschlechtsunterschiede bei psychosozialen Faktoren, sowie dysfunktionalem Essverhalten und Übergewicht und Adipositas. Zur Überprüfung der Fragestellung wurde eine mHealth Intervention (I-GENDO App) gestaltet, die psychosoziale Faktoren von Übergewicht und Adipositas individualisiert und gendersensibel bearbeitet hat. Eine Stichprobe von N=213 Menschen mit Übergewicht und Adipositas (67.1% weiblich) wurde in einem randomisierten Kontrollstudiendesign untersucht. Die Nutzung der 12-wöchigen mHealth Intervention wirkte sich kurzfristig positiv auf das dysfunktionale Essverhalten der Teilnehmenden aus. Zudem blieb der Effekt auf das restriktive und externale Essverhalten bei den weiblichen Teilnehmenden auch 12 Monate nach Beendigung der Intervention nachhaltig bestehen. Es zeigten sich nur geringe Effekte hinsichtlich einer Gewichtsreduktion.

Darüber hinaus ist das Wissen um das Vorliegen von Essstörungen bei Menschen mit Übergewicht

und Adipositas relevant, da diesen aufgrund der Komplexität der Symptomatik sowie der hohen Komorbidität mit anderen Störungsbildern eine spezielle Therapie angeboten werden sollte. Food Addiction ist bisher nicht als eigenständiges Störungsbild anerkannt, sondern wird meist als Syndrom anderer Essstörungen verstanden. Die Ergebnisse der hier präsentierten Studie deuten darauf hin, dass eine relevante Subgruppe (15%) von Menschen mit Übergewicht und Adipositas die Diagnosekriterien einer Food Addiction erfüllen, sowie Defizite in der Inhibitionsfähigkeit aufweisen und impulsive Verhaltensweisen zeigen, die auch bei Substanzkonsumstörungen beschrieben werden. Der Einfluss von Food Addiction auf die Effektivität von Gewichtsreduktionsmaßnahmen muss in zukünftigen Studien systematisch untersucht werden.

Zusammenfassend lässt sich folgern, dass die Bearbeitung psychosozialer Faktoren eine sinnvolle Ergänzung bisheriger mHealth Lebensstilinterventionen darstellen kann. Diese sollten ferner auch suchtspezifische Therapieelemente umfassen. Um der Adipositaspandemie effizient und effektiv begegnen zu können, bedarf es der Entwicklung innovativer multimodaler digitaler Interventionen.

English Abstract

Since 1975, the prevalence of overweight and obesity has tripled, causing high expenditures for health care systems worldwide. Innovative strategies targeting overweight and obesity are warranted. Digital health interventions are cost-effective alternatives to analog interventions and can be tailored to individual needs of the users. Mobile (mHealth) interventions are easily implementable and usable in everyday life. Studies indicate good short-term effects of mHealth lifestyle-interventions on weight loss. The effectiveness is higher when combined with analog psychotherapy, which is however resource- and cost-intensive. That for, the implementation of psychological elements into mHealth interventions might be a cost-effective alternative to enhance the effectiveness of mHealth lifestyle-interventions. According to the Biopsychosocial Model of Overweight and Obesity, targeting psychosocial factors of overweight and obesity might improve dysfunctional eating styles and subsequently cause weight loss. Research indicates gender disparities in psychosocial factors, dysfunctional eating styles and overweight and obesity. Therefore, a tailored gender-sensitive mHealth app intervention (I-GENDO app) was developed, targeting psychosocial factors of overweight and obesity. A randomized-controlled trial aimed to evaluate the effectiveness of the 12-week long intervention on dysfunctional eating styles and weight in N = 213 (67.1% female) individuals with overweight and obesity. Short-term effects of the intervention on dysfunctional eating styles were found. Moreover, the female participants of the intervention group could improve external and restrained eating styles sustainably even 12 months after intervention. Yet, only small effects on weight loss were detected.

In addition, eating disorders as clusters of psychosocial factors are of particular interest in obesity treatment, since people suffering from such disorders need specialized treatment targeted to the complex symptomatology. Food addiction is currently not an officially recognized diagnose. That is, among other things, due to the overlap of Food addiction symptoms with those of other eating

disorders. In the third study presented in that thesis, Food addiction was analyzed in individuals with overweight and obesity, who did not suffer from other eating disorders. The results indicated that a relevant subgroup (15%) of individuals with overweight and obesity fulfill the criteria of Food addiction. As known from substance use disorders, the subgroup of individuals with Food addiction showed typical impairments in inhibition processes and impulsive behaviors. The influence of Food addiction on the effectiveness of weight loss interventions should systematically investigated.

Taking together, targeting psychosocial factors of overweight and obesity might improve the short- and long-term effectiveness of common mHealth lifestyle-interventions. Furthermore, future interventions should implement therapy elements targeting addiction-related behaviors. To face the obesity pandemic, there is a need for innovative multimodal digital obesity treatment.

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Abkürzungen

AC: Action Cancelation
AICA-S: Scale for the Assessment of Internet and Computer game Addiction
AN: Anorexia Nervosa
AUDIT: Alcohol Use Disorders Identification Test
AW: Action Withdrawal
BES: Binge Eating Störung
BIS-15: Barratt Impulsiveness Scale
BMI: Body Mass Index
BN: Bulimia Nervosa
BSI-18: Brief Symptom Inventory
DD: Delay Discounting
DEBQ: Dutch Eating Behaviour Questionnaires
DSM: Diagnostic and Statistical Manual of Mental Disorders
eHealth: Nutzung von Informations- und Kommunikationstechnologien im Gesundheitswesen
e-Mental Health: eHealth bei psychischen Störungen
FA: Food Addiction
FRIS: Fragebogen zur Messung nahrungsbezogener Inhibitionsfähigkeit
GRM: Gewichtsreduktionsmaßnahme
ICD: International Statistical Classification of Diseases and Related Health Problems
IG: Interventionsgruppe
I-GENDO: Gendersensible Erweiterung herkömmlicher Gewichtsreduktionsprogramme bei Übergewicht und Adipositas: eine personalisierte Smartphone-App
IPQ-R: Illness Perception Questionnaire (revidiert)
KG: Kontrollgruppe
mHealth: Nutzung von Smartphone-, oder Tablet-basierte App-Interventionen im Gesundheitswesen
NGS: Negative Gewichtsbezogene Selbststereotypisierung
PHQ-9: Patient Health Questionnaire
RCT: Randomisierte Kontrollstudie
RS: Reward Sensitivity
SWE: Skala zur allgemeinen Selbstwirksamkeit
WBIS: Weight Bias Internalization Scale
WHO: Weltgesundheitsorganisation
YFAS-2: Yale Food Addiction Scale 2

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1. Theorie

1.1 Definition, Epidemiologie und Kosten von Übergewicht und Adipositas

Laut der Weltgesundheitsorganisation (WHO) kann zwischen Übergewicht und Adipositas (Grad I-III) aufbauend auf dem Body Mass Index (BMI) unterschieden werden (Tabelle 1). Dieser Index ist der Quotient aus dem Körpergewicht und der -größe in Meter zum Quadrat (kg/m^2).

Tabelle 1: Gewichtsklassifikation bei Erwachsenen nach Definition der WHO

Gewichtskategorie	BMI (kg/m^2)
Untergewicht	< 18.5
Normalgewicht	18.5 – 24.9
Übergewicht	25.0 – 29.9
Adipositas Grad I	30.0 – 34.9
Adipositas Grad II	35.0 – 39.9
Adipositas Grad III	≥ 40.0

Die WHO erkennt Adipositas als nichtübertragbare Krankheit an, definiert als eine starke Vermehrung an Köperfett, die über das Normalmaß hinausgeht, und gesundheitlichen Schaden verursachen kann (WHO Consultation on Obesity & World Health Organization, 2000). In der elften Revision des *International Statistical Classification of Diseases and Related Health Problems* (ICD-11) wird Adipositas als endokrine, Ernährungs- und Stoffwechselerkrankung eingruppiert (WHO, 2019). In Deutschland wurde Adipositas lange Zeit nicht als Krankheit anerkannt. Am 03. Juli 2020 hat der Deutsche Bundestag jedoch im Rahmen der *Nationalen Diabetes Strategie* ein Papier zur Abstimmung gebracht, das u.a. auch den Weg zur Anerkennung der Adipositas und die Kostenübernahme der Behandlung durch die Krankenkassen in Deutschland vorantreiben soll (ÄrzteZeitung, 2020).

Von 1975 bis heute hat sich die Zahl der Menschen mit Übergewicht und Adipositas weltweit nahezu verdreifacht. Global sind 39.0% der Menschen von Übergewicht und 13.0% von Adipositas betroffen (WHO, 2021). In Deutschland sind 34.5% der Erwachsenen von Übergewicht (BMI: 25.0-29.9 kg/m²) und 19.0% von Adipositas (BMI: 30.0 kg/m² oder höher) betroffen (Schienkiewitz et al., 2022). Mehr Männer (41.3%), als Frauen (27.6%) haben Übergewicht, jedoch zeigen sich keine Geschlechtsunterschiede in der Prävalenz von Adipositas. Die Prävalenz von Übergewicht und Adipositas steigt mit zunehmendem Alter an, bis der Zusammenhang ab dem 70. Lebensjahr wieder abnimmt (Ng et al., 2014).

Betroffene mit Übergewicht und Adipositas leiden unter einer Vielzahl von physischen und psychischen Begleit- und Folgeerkrankungen, wodurch die Kosten für die Gesundheitssysteme weltweit dramatisch ansteigen (Chu et al., 2018). Dabei unterscheidet man zwischen direkten Kosten, also solchen die durch die Behandlung der Erkrankung und der damit verbundenen Komorbiditäten entstehen, und indirekten Kosten, die beispielsweise durch eine krankheitsbedingte Arbeitsunfähigkeit, oder vorzeitige Berentung entstehen. Die direkten Kosten von Adipositas und Übergewicht betragen jährlich in Deutschland rund 29.4 Milliarden Euro, die indirekten Kosten rund 33.7 Milliarden Euro (Effertz et al., 2016). Adipositas gilt als der größte Risikofaktor für die Entwicklung des Metabolischen Syndroms, einem Cluster von Symptomen, die mit einem erhöhten Risiko für kardiovaskuläre und metabolische Erkrankungen einhergehen (Samson & Garber, 2014). Je höher der Grad der Adipositas, desto mehr sinkt die Lebenserwartung Betroffener. In Deutschland versterben jährlich rund 100.000 Menschen frühzeitig an den Folgen von Adipositas (Effertz et al., 2016).

Aufgrund der rasanten Zunahme von Übergewicht und Adipositas weltweit, sowie den enormen Kosten, die dadurch für die Gesundheits- und Sozialsysteme entstehen, bedarf es der Entwicklung und des Angebots effektiver und effizienter Strategien in der Adipositastherapie.

1.2 Die Behandlung von Übergewicht und Adipositas

Nach den Empfehlungen der interdisziplinären S3-Leitlinie zur *Prävention und Therapie der Adipositas* besteht das Hauptziel der Adipositastherapie darin, Gewicht zu reduzieren und langfristig zu stabilisieren, sowie relevante Risikofaktoren, Adipositas-assoziierte Erkrankungen und psychosoziale Auswirkungen zu mindern (Hauner et al., 2014). Je nach Schweregrad sollte eine Gewichtsreduktion von 5% (BMI: 25.0-34.9 kg/m²) bis 10% (BMI: ≥ 35.0 kg/m²) des Ausgangsgewichtes innerhalb von sechs bis zwölf Monaten angestrebt werden. Es wird eine multimodale Therapie mit den drei Schwerpunkten Ernährungs-, Bewegungs- und Verhaltenstherapie empfohlen, die bei schweren Komorbiditäten oder erfolglosen Abnehmversuchen mit einer adjuvanten medikamentösen Therapie unterstützt werden kann. Bei einem BMI über 40.0 kg/m² und erfolgloser konservativer Behandlung, wird ein Adipositas-chirurgischer Eingriff empfohlen. Lebensstilinterventionen zielen auf eine Veränderung des Bewegungs- und Ernährungsverhaltens, und werden nur teilweise um verhaltenstherapeutische Elemente wie Psychoedukation oder Selbstbeobachtungen ergänzt werden (Banning, 2005). Diese erzielen kurzfristig meist zufriedenstellende Gewichtsreduktionen von 5-10% des Ausgangsgewichts, der Effekt lässt jedoch langfristig nach (in: Becker et al., 2015, S.28-30). Intensive psychotherapeutische Behandlungen zeigen stärkere kurzfristige Effekte (in: Becker et al., 2015, S.25-26). Aufgrund des hohen Aufwands werden allerdings in bisherigen Studien meist nur kurze Katamnesezeiträume untersucht, weswegen die Beurteilung der Nachhaltigkeit der Effekte erschwert ist (Shaw et al., 2005).

Zur effektiven Behandlung von Übergewicht und Adipositas bedarf es einer multimodalen Therapie, welche Lebensstilinterventionen, um psychotherapeutische Elemente ergänzt. Analoge Angebote sind dabei meist ressourcenintensiv.

1.2.1 Digitale Interventionen in der Behandlung von Übergewicht und Adipositas

In den vergangenen Jahrzehnten sind immer mehr digitale Gesundheitsinterventionen weltweit entwickelt worden (Haring, 2019; Kay et al., 2011). Laut der WHO ist eHealth definiert als die Nutzung von Informations- und Kommunikationstechnologien im Gesundheitswesen mit dem Hauptziel die Kosten der Gesundheitsversorgung zu verringern (WHO, 2023). Dazu zählen neben der Behandlung von Betroffenen beispielsweise auch die Digitalisierung von PatientInnendaten (in: Haring, 2019, S2-13). Ein Teilbereich von eHealth stellt E-Mental Health dar, in welchem Interventionen auf die Unterstützung und Verbesserung psychischer Erkrankungen abzielen (in: Haring, 2019, S.49). Smartphone-, oder Tablet-basierte App-Interventionen werden unter dem Begriff mHealth zusammengefasst und sind besonders gut in den Alltag von Betroffenen implementierbar (Wang et al., 2017).

Fast 67 Millionen Menschen in Deutschland nutzen das Internet regelmäßig (ARD/ZDF Forschungskommission, 2021). Im Jahr 2021 besaßen ca. 87 % aller Erwachsenen und Jugendlichen über 14 Jahren ein Smartphone und 27 % gaben an regelmäßig mHealth Interventionen zu nutzen (Initiative D21, 2022).

Bei den meisten kommerziell angebotenen mHealth Gewichtsreduktionsmaßnahmen (GRMs) handelt es sich um Lebensstilinterventionen (Pagoto et al., 2013). Mithilfe von mHealth Lebensstilinterventionen können Ernährungsgewohnheiten und deren gesundheitsbezogene Auswirkungen verbessert werden (Villinger et al., 2019). Bisherige Interventionen machen dabei meist Gebrauch von den Elementen: Zielsetzung, Selbstbeobachtung und Feedback. Wie in analogen Settings, sind digitale Lebensstilinterventionen kurzfristig meist sehr effektiv, allerdings lässt der Effekt langfristig nach und es kommt zu einer Wiederzunahme an Gewicht (Jeffery et al., 2000; Ross Middleton et al., 2012).

In einer kürzlich veröffentlichen Meta-Analyse wurde die Effektivität von 34 mHealth Interventionen in Bezug auf eine Reduktion des Gewichts hin untersucht, sowie Subgruppenanalysen zu Appfeatures

und analogen Behandlungselementen in Kombination mit der App durchgeführt (Antoun et al., 2022). Dabei wurde der Gewichtsverlust in kg nach 3 und 6 Monaten nach der Eingangserhebung berichtet. Insgesamt konnte ein gemittelter Gewichtsverlust von 1.99 kg nach 3 Monaten und 2.80 kg nach 6 Monaten berechnet werden. Eine höhere Effektivität zeigte sich bei der Kombination mit analogen verhaltenstherapeutischen Elementen. Aufgrund der meist kurzen Beobachtungszeiträume können bisher keine validen Rückschlüsse bzgl. der Nachhaltigkeit der Effekte gezogen werden (Wang et al., 2020). In einer Studie von Thomas et al. (2019) wurden gewichtsbezogene psychoedukative Elemente über eine Smartphone-App vermittelt. Dabei konnten die Teilnehmenden der Smartphone-Gruppe eben so viel Gewicht reduzieren, wie die Teilnehmenden der aktiven Kontrollgruppe, welche an analogen gruppenbasierten Settings teilnahmen.

MHealth Interventionen bieten die Möglichkeit zur kosteneffizienten Behandlung von Adipositas und Übergewicht. Bei den bisherigen Angeboten handelt es sich jedoch meist um Lebensstilinterventionen, deren kurzfristige Effektivität durch die Kombination mit analogen psychotherapeutischen Elementen erhöht werden kann. Erste Ergebnisse deuten darauf hin, dass psychoedukative Elemente auch digital vermittelt werden können (Thomas et al., 2019). Bisher mangelt es jedoch an Studien, die ein breiteres Angebot an wissenschaftlich fundierten psychologischen Elementen digital in die Behandlung implementieren und die Nachhaltigkeit der Effekte untersuchen.

1.2.2 Individualisierung in der Behandlung von Übergewicht und Adipositas

Die interdisziplinäre S3-Leitlinie zur *Prävention und Therapie der Adipositas* empfiehlt weiter, dass Menschen mit Adipositas eine individualisierte und evidenzbasierte Therapie angeboten werden sollte, welche sich an den persönlichen Umständen der Betroffenen orientieren sollte (Hauner et al., 2014). Die meisten mHealth GRMs verfolgen jedoch einen „One-Size-Fits-All“ Ansatz, obwohl es Hinweise darauf gibt, dass individualisierte Interventionen eine bessere Effektivität aufweisen (Davis

et al., 2020; DiClemente et al., 2019; Ryan et al., 2019). Im Englischen wird das „Zuschneiden“ einer Intervention auf die individuellen Bedürfnisse oder Charakteristika einer Person als Tailoring bezeichnet (Noar et al., 2011). Dabei unterscheidet man zwischen Tailoring, das basierend auf Daten einer Person von dem Programm, oder dem Versuchsleiter vorgenommen wird (Computer-Basiertes Tailoring) und solchem, bei dem die Person selbst die Inhalte der Intervention aussuchen kann (Selbstständiges Tailoring). Studienteilnehmende fühlen sich von individualisierten Interventionen persönlicher angesprochen und sind meist zufriedener und adhärenter, wodurch die Effektivität der Interventionen erhöht ist (Butryn et al., 2020; Calugi et al., 2020; Cavero-Redondo et al., 2020; Krebs et al., 2010; Puls et al., 2019; Ryan et al., 2019).

Obwohl empfohlen wird, dass Behandlungselemente in der Adipositastherapie individualisiert angeboten werden sollten, verfolgen die meisten GRMs einen „One-Size-Fits-All“ Ansatz. Darüber hinaus bedarf es der Implementierung psychotherapeutischer Elemente in die digitale Adipositastherapie. Mithilfe von Tailoringelementen könnten psychosoziale Bedingungsfaktoren von Adipositas und Übergewicht individualisiert bearbeitet werden, wodurch die Effektivität und Nachhaltigkeit digitaler Interventionen gesteigert werden könnte (Chalk, 2004).

1.3 Biopsychosoziales Modell der Entstehung und Aufrechterhaltung von Adipositas

Übergewicht entsteht im Zuge einer chronisch positiven Energiebilanz, bei der mehr Energie aufgenommen, als abgegeben wird. Ursächlich dafür sind neben der Stoffwechselleistung Betroffener, deren Ernährungs- und Bewegungsverhalten (Lavie et al., 2018). Genetische, soziokulturelle und psychosoziale Bedingungsfaktoren wirken sich auf das Ernährungs- und Bewegungsverhalten und damit auf das Gewicht aus. Abbildung 1 zeigt eine vereinfachte Darstellung des biopsychosozialen Modells der Entstehung und Aufrechterhaltung von Übergewicht und Adipositas nach Lehrke und Laessle (2009).

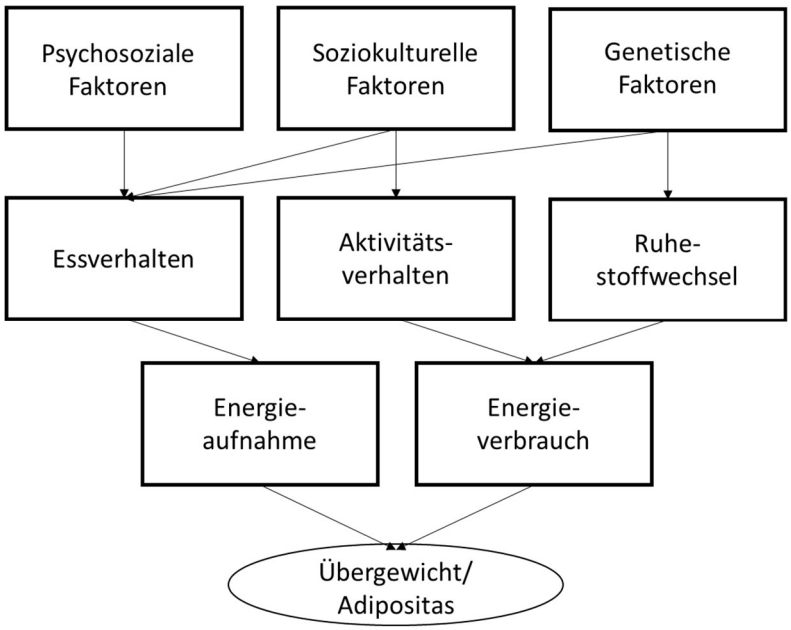

Abbildung 1: Vereinfachte Darstellung des biopsychosozialen Modells der Entstehung und Aufrechterhaltung von Übergewicht und Adipositas nach Lehrke & Laessle, 2009.

Im folgenden Abschnitt sollen psychosoziale Bedingungsfaktoren von Übergewicht und Adipositas vorgestellt, sowie deren Einfluss auf das Essverhalten beschrieben werden.

1.4 Psychosoziale Bedingungsfaktoren von Übergewicht und Adipositas

Stress wird als Reaktion des Organismus auf interne oder externe Stressoren verstanden, wobei die Stressreaktion durch die Wahrnehmung der Gefahr und die Einschätzung der eigenen Möglichkeiten im Umgang damit beeinflusst wird (in: Glanz et al., 2008, S. 211-230). Im Umgang mit Stress kann zwischen adaptiven und maladaptiven Bewältigungsmechanismen unterschieden werden, wobei letztere meist nur kurzfristig zu einer Reduktion des Stresses beitragen und langfristig oft negative Folgen haben (bspw. Alkoholkonsum). In Phasen von erhöhtem Stress nehmen die meisten Menschen (rund 70%) an Gewicht zu (Adam & Epel, 2007). Aufgrund des Einflusses vor allem hochkalorischer und zuckerreicher Nahrungsmittel auf das Belohnungssystem des Gehirns, kann der gesteigerte Verzehr als Stressbewältigungsmechanismus eingesetzt werden. Unter dem Einfluss von chronischem Stress, kommt es zu einer Steigerung des Kortisolspiegels, wodurch wiederum das Belohnungssystem

beeinflusst, und die Einlagerung viszeraler Fettzellen erhöht wird (Lavie et al., 2018).

Übergewicht und Adipositas werden oft mit negativen Vorurteilen verbunden und viele Betroffene erfahren gewichtsbezogene Diskriminierung im Alltag und Beruf (Chu et al., 2019; Puhl & Heuer, 2009). Trotz der weltweiten Zunahme von Übergewicht und Adipositas, hat sich das Schönheitsideal von Frauen in den vergangenen Jahrhunderten und –zehnten immer weiter in Richtung eines schlankeren Körpers verändert. In der Konsequenz erleben mehr Frauen gewichtsbezogene Stigmatisierung, gleichzeitig zeigen Männer mehr gewichtsbezogene Vorurteile, vor allem gegenüber Frauen (Boswell & White, 2015). Diese Diskriminierung zeigt sich auch in der Arbeitswelt. Frauen mit Übergewicht wird Inkompetenz unterstellt, zudem verdienen sie weniger (Chu et al., 2019). Durch die Stigmatisierungserfahrung ziehen sich viele Betroffene sozial zurück, was zum Erleben von Einsamkeit und Gefühlen von Niedergeschlagenheit beitragen, und die psychische Morbidität steigern kann (Hajek et al., 2021).

Es konnte gezeigt werden, dass das Erleben von gewichtsbezogener Diskriminierung mit einer erhöhten Nahrungsaufnahme (Schvey et al., 2011) und Heißhungerattacken (Almeida et al., 2011) in Verbindung steht. Darüber hinaus können negative gewichtsbezogene Vorurteile, mit denen Betroffene oft selbst in Form von Diskriminierung oder Mobbing konfrontiert sind, internalisiert werden (Puhl & Heuer, 2009). Eine solche negative gewichtsbezogene Selbststereotypisierung (NGS) vermittelt den Zusammenhang zwischen der Erfahrung von gewichtsbezogener Diskriminierung und dysfunktionalem Essverhalten (Durso et al., 2012), und steht im Zusammenhang mit einer erhöhten psychischen Morbidität (Sutin et al., 2015).

Frauen sind besorgter um ihr Gewicht und ihre Figur und zeigen häufiger NGS, als Männer (Boswell & White, 2015). Auf physiologischer Ebene kann es durch das Erleben von Diskriminierung und NGS zur Aktivierung der Stresssysteme des Körpers kommen (Lavie et al., 2018). Hochkalorische Nahrungsmittel können dann im Sinne eines circulus virtiosus wie bereits oben beschrieben als Bewältigungsmechanismus für den erlebten Stress eingesetzt werden (Tomiyama, 2014). Junge

Frauen mit Übergewicht sind besonders anfällig für interpersonellen Stress, welcher zu einer Zunahme von Gewichts- und Figursorgen führen kann (Dougherty et al., 2022). Frauen berichten allgemein ein höheres wahrgenommenes Stressniveau, als Männer (Anbumalar et al., 2017).

Auch Defizite in der Emotionswahrnehmung und –regulation werden in Zusammenhang mit dysfunktionalem Essverhalten beschrieben (Prefit et al., 2019). Vor allem die Anwendung maladaptiver Emotionsregulationsmechanismen wie Verdrängung, Vermeidung oder Grübeln, kann zu einem gestörten Essverhalten beitragen (Aldao et al., 2010). Dabei scheinen Frauen eine höhere Grübelneigung aufzuweisen, als Männer (Tamres et al., 2002). Der Verzehr großer Nahrungsmengen bei emotionaler Belastung kann als Mechanismus zur Verdrängung aversiver Affekte verstanden werden (Prefit et al., 2019). Erlebt der oder die Betroffene dabei einen Kontrollverlust über die aufgenommene Nahrungsmenge, wird dies als Essanfall definiert. Je regelmäßiger Betroffene Essanfälle erleben, desto höher ist das berichtete Gewicht (Picot & Lilenfeld, 2003). Menschen mit Übergewicht und Adipositas haben eine gesteigerte Impulsivität, sowie eine geringere nahrungsbezogene Inhibitionsfähigkeit, als Menschen mit Normalgewicht (Houben et al., 2014; Mobbs et al., 2010).

Langjährige Betroffene mit Übergewicht und Adipositas, vor allem solche mit einem hohen BMI und vielen erfolglosen Diätversuchen, leiden meist unter einem negativen Selbst- und Körperbild, sowie einer geringen Selbstwirksamkeit (Foster et al., 1997; Schwartz & Brownell, 2004). Ein erfolgreicher Gewichtsverlust ist jedoch mit einer hohen Selbstwirksamkeit und intrinsischen Motivation, sowie positiver Stimmung und einem positiven Körperbild verbunden (Teixeira et al., 2015).

Eine geringe nahrungsbezogene Inhibitionsfähigkeit bei hoher allgemeiner Impulsivität, Probleme in der Emotionswahrnehmung und –regulation, ein geringes Selbstbild, die Internalisierung von gewichtsbezogenen Vorurteilen, sowie eine geringe Selbstwirksamkeit und maladaptive Stressbewältigungsstrategien, werden als psychosoziale Bedingungsfaktoren von Übergewicht und Adipositas beschrieben.

Aber auch psychische Störungen stehen im Zusammenhang mit Übergewicht und Adipositas. Das Risiko für die Entstehung einer klinischen Depression ist bei Menschen mit Übergewicht und Adipositas erhöht (Luppino et al., 2010). Vor allem Frauen mit starkem Übergewicht sind besonders gefährdet an Depressionen zu erkranken (Pereira-Miranda et al., 2017). Jedoch kann es auch im Zuge einer depressiven Erkrankung zu einer Gewichtszunahme kommen, weswegen von einem bidirektionalen Zusammenhang zwischen Übergewicht und Depressionen ausgegangen werden muss (Luppino et al., 2010). Durch die Belastung in Folge gewichtsbezogener Diskriminierung, kann vor allem bei Kindern auch eine Zunahme sozialer Ängste festgestellt werden (in: Herpertz et al., 2022, S.453-459).

Essstörungen können als Cluster psychosozialer Bedingungsfaktoren von Übergewicht, aber auch Untergewicht bei Anorexia Nervosa (AN), verstanden werden. So ist die Prävalenz der Binge-Eating-Störung (BES) in Stichproben von Menschen mit Übergewicht und Adipositas, die an GRMs teilnehmen, wesentlich höher (bis zu 30%) (Dingemans et al., 2002), als in der Normalbevölkerung (ca. 1.9%) (Kessler et al., 2013). Gleichzeitig scheinen Betroffene mit BES weniger von den angebotenen GRMs zu profitieren (Blaine & Rodman, 2007). Sowohl die BES, als auch die Bulimia Nervosa (BN) sind mit einem höheren Körpergewicht und vermehrten langfristig erfolglosen Diätversuchen, verbunden (in: Herpertz et al., 2022, S.495-499; Kessler et al., 2013).

Aufgrund der Komplexität ihrer Symptome und der Komorbidität mit anderen Störungsbilder, müssen Essstörungen demnach in der Adipositastherapie besonders berücksichtigt werden. Von Relevanz ist dabei das Wissen um das Vorliegen einer Essstörung, sowie das Angebot störungsspezifischer Therapieelemente. Dabei wird seit einigen Jahrzehnten eine wissenschaftliche Debatte über die Existenz eines bisher nicht anerkannten Störungsbildes, der Food Addiction (FA), gehalten, welche im Folgenden genauer beleuchtet werden soll.

1.4.1 Food Addiction

Einige Menschen mit Übergewicht und Adipositas empfinden sich selbst als „esssüchtig“, was sich in einem Kontrollverlust über das Essen, emotionalem Essverhalten und einem starken Verlangen (Craving) nach bestimmten Nahrungsmitteln, auch ohne das Vorhandensein von Hunger, äußert (Davis et al., 2013; Meule, 2015). Das Konzept der Nahrungs- oder Esssucht wurde erstmals 1956 von Theron Randolph vorgestellt, welcher Parallelen zwischen dem Essverhalten einiger Menschen mit Übergewicht und dem Konsumverhalten bei Substanzkonsumstörungen feststellte (Randolph, 1956). In den 60er und 70er Jahren haben sich Selbsthilfegruppen in den USA zu den sogenannten „Overeaters Anonymous“ zusammengeschlossen, welche das 12-Punkte Programm der anonymen Alkoholiker als Vorlage nahmen (Meule, 2015). Neurobiologische Untersuchungen zeigen vergleichbare Aktivierungsmuster des dopaminergen Belohnungssystems unter dem Konsum zucker- und fetthaltiger Nahrungsmittel, wie unter Drogen- oder Alkoholkonsum (Beitscher-Campbell et al., 2016; Gearhardt et al., 2011; Grosshans et al., 2012; Novelle & Diéguez, 2018). In der wissenschaftlichen Community wird FA jedoch seit jeher und bis heute kontrovers diskutiert (Gearhardt & Hebebrand, 2021; Hebebrand & Gearhardt, 2021). FA ist bisher nicht als eigenständiges Störungsbild anerkannt. Basierend auf den Kriterien für Substanzkonsumstörungen entsprechend der fünften Auflage des *Diagnostic and Statistical Manual of Mental Disorders* (DSM-5) können jedoch elf Symptome unterschieden werden, welche mithilfe eines standardisierten Fragebogens (Yale Food Addiction Scale II, YFAS II) (Gearhardt et al., 2016; Meule et al., 2017) erfasst werden können: 1) der Konsum sehr großer Mengen an Nahrung, oder größerer Mengen als geplant, 2) erfolglose Versuche den Konsum zu reduzieren 3) großer Zeitaufwand für Beschaffung und den Konsum von Nahrungsmitteln, oder für die Erholung von einem Überkonsum 4) wichtige Aktivitäten werden zugunsten des Essverhaltens aufgegeben, 5) der übermäßige Konsum hat körperliche oder emotionale Konsequenzen, 6) Konsum immer größerer Nahrungsmengen, um gewünschten Effekt zu erhalten, 7) Entzugssymptome, wenn bestimmte Nahrungsmittel nicht verfügbar sind, 8) häufiger und starker Drang nach bestimmten Nahrungsmitteln, 9) Verpflichtungen werden aufgrund des Essverhaltens

vernachlässigt, 10) der übermäßige Konsum wird trotz interpersoneller und sozialer Probleme fortgesetzt, 11) der übermäßige Konsum wird auch in riskanten Situationen (bspw. beim Autofahren) fortgesetzt.

Analog zu Substanzkonsumstörungen zeigen Individuen mit FA eine hohe Impulsivität (VanderBroek-Stice et al., 2017). Impulsivität kann als multidimensionales Konstrukt verstanden werden, welches durch Defizite in der Inhibitionsfähigkeit und einer geringen Selbstkontrolle charakterisiert ist und im Wesentlichen über drei Komponenten beschrieben wird: impulsive Persönlichkeitsstruktur (allgemeine Impulsivität), impulsive Handlungen und impulsive Entscheidungen (Bari & Robbins, 2013; Hofmann et al., 2009; Mole et al., 2015). Individuen mit FA konsumieren meist schnell verfügbare hochkalorische Nahrung und zeigen Defizite in der Kontrolle von Essimpulsen (Meule, 2017; Preuss et al., 2019; VanderBroek-Stice et al., 2017). Männer zeigen eine höhere allgemeine Impulsivität (Cross et al., 2011), jedoch berichten mehr Frauen von impulsivem Essverhalten, welches mit einem höheren BMI assoziiert wird (Macht, 1999; Mole et al., 2015).

In Deutschland erfüllen ca. 7.9 % der Gesamtbevölkerung die Kriterien einer FA, wobei die Prävalenz bei Menschen mit Übergewicht und Adipositas erhöht ist (17.2 %-25.0 %); auch finden sich höhere Prävalenzen bei Frauen im Vergleich zu Männern (Hauck et al., 2017; Pursey et al., 2014). Unter Teilnehmenden an GRMs ist die Prävalenz deutlich erhöht (34.5 %-38.0 %) (Meule et al., 2015; Vidmar et al., 2021). Der Zusammenhang zwischen FA und Übergewicht wird von einigen Forschenden über das Vorhandensein von relevanten Komorbiditäten, v.a. Essstörungen, erklärt (Chao et al., 2019; Eichen et al., 2013; Lent et al., 2014). Tatsächlich ist die Prävalenz von FA bei PatientInnen mit BES (40.0%-50.0%) und BN (ca. 80.0%) deutlich erhöht (De Vries & Meule, 2016; Gearhardt et al., 2014). Daraus folgernd wird FA mitunter als Syndrom anderer Essstörungen verstanden (Chao et al., 2019; Eichen et al., 2013; Lent et al., 2014). Einige FA-Symptome gehen jedoch nicht in anderen Essstörungen auf, bspw. der hohe Zeitaufwand zur Nahrungsbeschaffung,

oder das Erholen von einem Überkonsum. Andere Symptome, wie der Kontrollverlust über das Essverhalten, überlappen nur teilweise mit denen anderer Essstörungen. Beispielswiese sind Essanfälle bei BES PatientInnen sehr oft mit einem Gefühl des Kontrollverlustes verbunden, aber Betroffene mit FA können diesen Kontrollverlust auch ohne das Vorhandensein von Essattacken empfinden, bspw. beim systematischen Absuchen (Grazing) der Wohnung nach bestimmten Nahrungsmitteln.

FA ist mit einem höheren BMI, starker NGS, einem geringen Selbstwert, einer hohen psychischen Belastung und geringen Lebensqualität assoziiert (Baldofski et al., 2016; Burmeister et al., 2013; Gearhardt et al., 2012; Minhas et al., 2021; Vidmar et al., 2021). Der Einfluss von FA auf die Effektivität von GRMs wird heterogen beschrieben (Burmeister et al., 2013; Clark & Saules, 2013; Fielding-Singh et al., 2019; Meule et al., 2015).

Die Studienlage deutet darauf hin, dass FA als eigenständiges Störungsbild und Cluster psychosozialer Bedingungsfaktoren von Übergewicht und Adipositas betrachtet werden kann. Bisher wird FA jedoch oft als Syndrom anderer Essstörungen betrachtet. Es gibt bisher keine Studien, die FA in einer Stichprobe von PatientInnen ohne BES oder BN untersuchen.

1.5 Dysfunktionales Essverhalten

Unter emotionalem Essverhalten versteht man eine Nahrungsaufnahme, die als unmittelbare Antwort auf eine emotionale Erregung erfolgt (van Strien et al., 2013). Emotionales Essverhalten wird durch Probleme in der Emotionswahrnehmung und –regulation bedingt, sowie durch ein übermäßig stark ausgeprägtes restriktives Essverhalten, und wird als Moderator zwischen Depressionen und Adipositas verstanden (van Strien, 2018). Die Betroffenen überwachen und zügeln ihr Essverhalten im Alltag besonders stark, jedoch reagieren sie auf emotionale Belastung mit einer Enthemmung des Essverhaltens, welches als Emotionsregulationsstrategie fungiert. Emotionales Essverhalten ist verbunden mit höherem Gewicht, schwererer depressiver Symptomatik und dem Konsum süßer

Speisen (Konttinen et al., 2010). Frauen führen ihr Übergewicht eher auf negative Emotionen zurück und berichten häufiger von emotionalem Essverhalten, als Männer (Henning et al., 2022; Larsen et al., 2006). Männer wenden seltener restriktives Essverhalten an, als Frauen (Nagl et al., 2016). Ein stark ausgeprägtes externales Essverhalten kann ebenfalls zur Entstehung und Aufrechterhaltung von Übergewicht und Adipositas beitragen. Externales Essverhalten wird ausgelöst durch eine erhöhte Sensibilität gegenüber äußeren Essensreizen (bspw. dem Duft gebrannter Mandeln auf dem Weihnachtsmarkt), und ist das am häufigsten vorkommende Essverhalten innerhalb der Bevölkerung. In der Folge geben Betroffene dem Drang zu Essen häufiger nach, zeigen also Defizite in der nahrungsbezogenen Inhibitionsfähigkeit. Externales Essverhalten ist zudem positiv assoziiert mit emotionalem Essverhalten (Van Strien et al., 1995). In der Kombination entsteht ein Teufelskreis, bei dem Betroffene emotionsregulatorisch und extern-initiiert essen, unabhängig von internen Hungerreizen.

Obwohl übermäßig stark ausgeprägtes restriktives Essverhalten zur Entstehung von emotionalem Essverhalten und Essstörungen beiträgt, ist ein mäßig ausgeprägtes restriktives Essverhalten protektiv für die Entstehung von Übergewicht und Adipositas (Teixeira et al., 2010). Eine Steigerung des restriktiven und Verringerung des emotionalen Essverhaltens sind Prädiktoren für einen erfolgreichen Gewichtsverlust bei Diäten (van Strien et al., 2009). Die Rolle des externalen Essverhaltens im Abnehmprozess scheint geringer zu sein. Jedoch zeigen Studien, dass externales Essverhalten den Prozess des Gewichthaltens nach Diäten negativ beeinflussen kann (Burton et al., 2007; Neumann et al., 2018). Insgesamt zeigen Männer seltener dysfunktionales Essverhalten als Frauen. Es gibt jedoch Hinweise darauf, dass dieses persistenter ist, als bei Frauen (Keel et al., 2007).

Psychosoziale Faktoren steigern das dysfunktionale Essverhalten und wirken sich dadurch auf die Entstehung und Aufrechterhaltung von Übergewicht und Adipositas aus.

1.6 Geschlecht und Gender bei Übergewicht und Adipositas

Wie bereits in den oberen Abschnitten beschrieben, zeigen sich Geschlechtsunterschiede in der Prävalenz und Ätiologie von Übergewicht und Adipositas. Es zeigt sich ebenfalls, dass sich die gesundheitlichen Folgen von Übergewicht und Adipositas bei Männern und Frauen unterscheiden. So trägt starkes Übergewicht bei Frauen zur Entstehung des Polyzystischen Ovarialsyndroms bei, einer Hormonstörung, welche zur Unfruchtbarkeit führen kann (Hu, 2003). Frauen mit Übergewicht und Adipositas haben ein erhöhtes Risiko für Krebserkrankungen, vor allem Brust- und Gebärmutterkrebs, und leiden häufiger unter Hypertension, während Männer meist unter Diabetes Typ II, Schlafapnoe und Hyperlipidämie leiden (Cooper et al., 2021; Kochkodan et al., 2018). Darüber hinaus sind Unterschiede in der Effektivität von GRMs bekannt. Frauen nehmen häufiger an GRMs teil, jedoch verlieren männliche Teilnehmende im Schnitt mehr Gewicht (Chin et al., 2016; Cooper et al., 2021). Ergebnisse bezüglich geschlechtsspezifischer Unterschiede in der Akzeptanz und Adhärenz mit GRMs sind heterogen und werden oft nicht ausreichend untersucht (Bautista-Castano et al., 2004; Greenberg et al., 2009; Klenk et al., 2017). Inwiefern die genannten Unterschiede durch biologische Determinanten oder soziokulturelle Prägungen des Geschlechtsbegriffes zustande kommen, kann zum Zeitpunkt der Behandlung nicht retrospektiv aufgeklärt werden. Eine Berücksichtigung dieser bei der Gestaltung neuer GRMs erscheint jedoch notwendig. Die computer-basierte Zuteilung von Interventionselementen basierend auf dem biologischen Geschlecht hat sich gegenüber geschlechtsneutralen Interventionen nicht als überlegen erwiesen (Sharkey et al., 2020). Die vorliegende Arbeit unterstützt die soziokulturelle Sichtweise von Gender als dimensionaler Ausprägung von gelebter Geschlechtsidentität (Schigl, 2018). Interventionen sollten demnach nicht geschlechtsspezifisch, sondern gendersensibel gestaltet werden. Bislang liegen jedoch keine Untersuchungen vor, die dies systematisch untersuchen würden.

1.7 Synopsis und Forschungsfragen

Übergewicht und Adipositas sind ein Gesundheitsproblem von pandemischem Ausmaß, mit erheblichen Kosten für die Gesundheitssysteme und dringenden Anforderungen an Regierungen weltweit. Kostengünstige und effektive Behandlungsangebote sind notwendig. Mobile digitale Gesundheitsinterventionen sind einfach in den Alltag Betroffener implementierbar, zudem eröffnen sie die Möglichkeit zur Individualisierung der Behandlung durch die Verwendung von Tailoring Elementen, durch die individuelle Faktoren, die zu Übergewicht und Adipositas beitragen, gezielt bearbeitet werden können. Frühere Studien weisen darauf hin, dass die Effektivität von GRMs in Kombination mit psychotherapeutischen Elementen erhöht ist. Basierend auf dem Biopsychosozialen Modell der Entstehung und Aufrechterhaltung von Übergewicht und Adipositas (Lehrke & Laessle, 2009, siehe Kap. 1.3), kann vermutet werden, dass durch eine Bearbeitung psychosozialer Faktoren von Übergewicht und Adipositas, dysfunktionales Essverhalten verbessert und das Gewicht Betroffener reduziert werden kann. Dabei scheint das Geschlecht bzw. die gelebte Geschlechtsidentität (Gender) einen Einfluss auf die Zusammenhänge auszuüben. Das Ziel dieser Arbeit ist es zu untersuchen, ob die Bearbeitung psychosozialer Faktoren von Übergewicht und Adipositas in der digitalen Adipositastherapie zu einer kurzfristigen und nachhaltigen Verbesserung des dysfunktionalen Essverhaltens und Gewichtsreduktion beitragen kann (Fragestellung 1, siehe Abb. 2). Ein erfolgreicher Gewichtsverlust wird in früheren Studien mit einer Reduktion des emotionalen und externalen Essverhaltens, sowie einer Steigerung des restriktiven Essverhaltens in Verbindung gebracht.

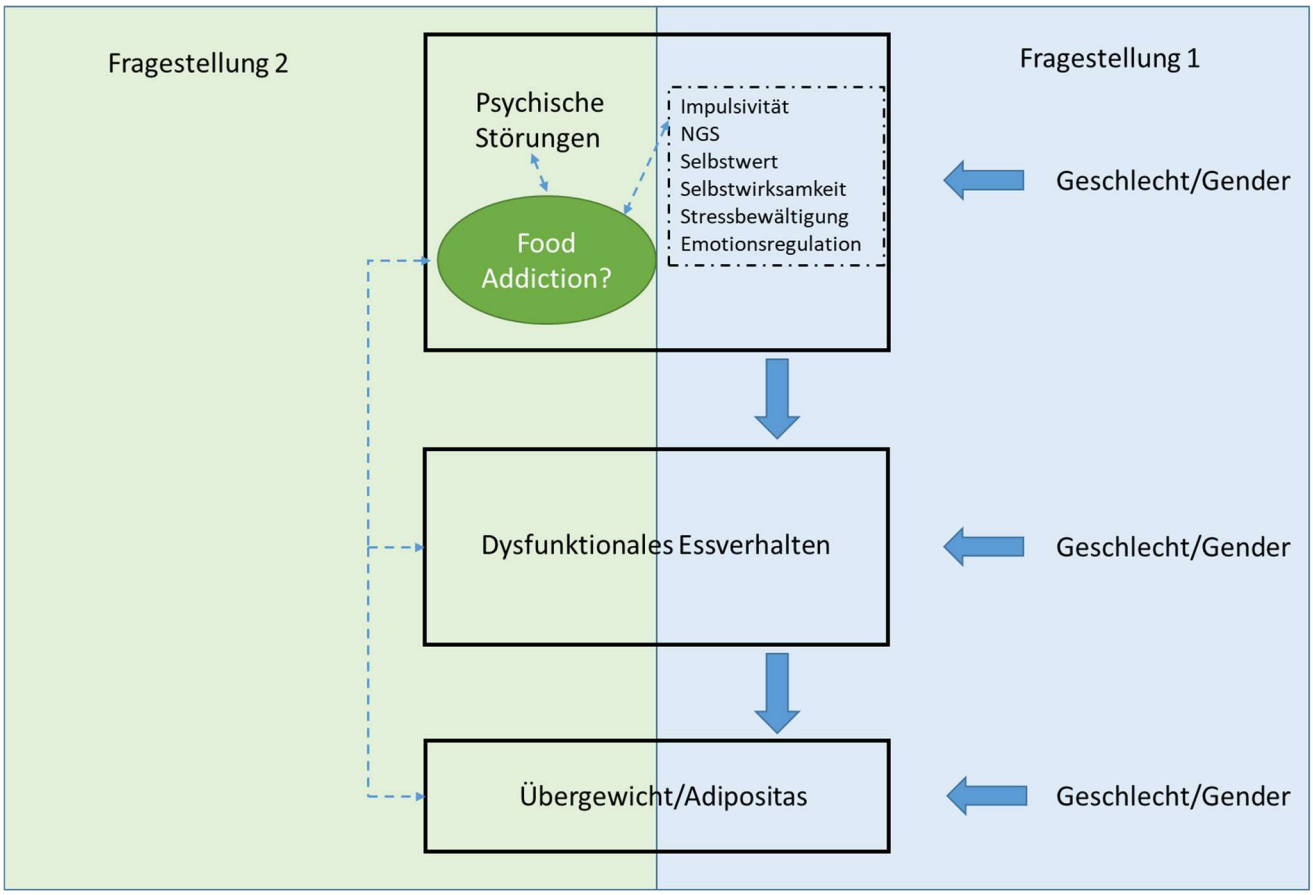

Abbildung 2: Modellhafte Darstellung der zu untersuchenden Fragestellungen basierend auf einer Adaption des Biopsychosozialen Modells zur Entstehung und Aufrechterhaltung von Übergewicht und Adipositas (Lehrke & Laessle, 2009)

Zur Untersuchung der Fragestellung 1, wurde eine mHealth Intervention entwickelt, die mithilfe computer-basierter Tailoringelemente psychosoziale Bedingungsfaktoren von Übergewicht und Adipositas bearbeitet. Um in früheren Studien berichtete Geschlechtsunterschiede zu berücksichtigen, ohne dabei dimensionale Ausprägungen von Geschlechtsidentität zu vernachlässigen, wurde die mHealth Intervention mithilfe von selbstständigen Tailoringelementen gendersensibel gestaltet.

Die folgenden Hypothesen werden untersucht:

H1: *Die Intervention kann individualisiert genutzt werden, d.h. die computer-basierten Tailoringelemente werden heterogen auf die Stichprobe verteilt* **(H1a)** *und die selbstständigen Tailoringelemente werden heterogen ausgewählt* **(H1b).**

H2: *Die Adhärenz und Zufriedenheit mit der App ist zufriedenstellend.*

H3: *Die mHealth Intervention hat einen kurzfristigen und nachhaltigen Effekt auf das dysfunktionale Essverhalten, indem das emotionale Essverhalten* **(H3a)** *und das externale Essverhalten* **(H3b)** *reduziert werden, das restriktive Essverhalten* **(H3c)** *jedoch erhöht wird.*

H4: *Die Teilnehmenden der Studie reduzieren kurzfristig und nachhaltig ihr Gewicht.*

Psychische Störungen, vor allem Essstörungen, können als Cluster psychosozialer Faktoren von Übergewicht und Adipositas verstanden werden. Aufgrund der Komplexität ihrer Symptome und der Komorbidität mit anderen Störungsbilder, müssen Essstörungen in der Adipositastherapie besonders berücksichtigt werden. Von Relevanz ist dabei das Wissen um das Vorliegen einer Essstörung, sowie das Angebot störungsspezifischer Therapieelemente. FA ist aufgrund der Nähe zu anderen Essstörungen bisher nicht als eigenständiges Störungsbild anerkannt. Ein weiteres Ziel dieser Arbeit ist es, Zusammenhänge von FA mit psychosozialen Faktoren, dysfunktionalem Essverhalten, sowie Übergewicht und Adipositas, getrennt von anderen Essstörungen zu betrachten und dadurch Evidenz in Bezug auf die Eigenständigkeit des Störungsbildes zu generieren (Fragestellung 2, Abb. 2).

Die folgende weitere Hypothese wurde untersucht:

H5: *In einer Stichprobe von Menschen mit Übergewicht und Adipositas, die weder von einer BES noch von einer BN betroffen sind, erfüllt eine Substichprobe die Kriterien einer FA Diagnose* **(H5a).** *Es zeigen sich Zusammenhänge zwischen FA und psychosozialen Faktoren, sowie dysfunktionalem Essverhalten und Übergewicht bzw. Adipositas* **(H5b).**

2. Methodik

2.1 Das „I-GENDO“ Projekt

Die Daten zur Beantwortung der Fragestellungen stammten aus einem Kooperationsprojekt zwischen dem Lehrstuhl für Klinische Psychologie und Psychotherapie der Otto-Friedrich-Universität Bamberg, der Professur für Pathopsychologie der Otto-Friedrich-Universität Bamberg und dem LWL-Universitätsklinikum Bochum der Ruhr-Universität Bochum, Klinik für Psychosomatische Medizin und Psychotherapie. Das Projekt mit dem Titel: *Gendersensible Erweiterung herkömmlicher Gewichtsreduktionsprogramme bei Übergewicht und Adipositas: eine personalisierte Smartphone-App* (I-GENDO) wurde vom 01.09.2017 bis zum 28.02.2022 vom Bundesministerium für Bildung und Forschung im Rahmen der Förderinitiative *Gesund- ein Leben lang* finanziert (01GL1719A/B). Die Studie wurde präregistriert (Deutsches Register für Klinische Studien: DRKS00016623) und von der Ethik-Kommission der Medizinischen Fakultät der Ruhr-Universität Bochum (Vorlage-Nr: 18-6415) votiert.

2.2 Studienablauf

Im Rahmen der ersten Studienphase von September 2017 bis November 2019 wurde ein modulares Appsystem in Zusammenarbeit mit dem externen Softwareanbieter groupXS Solutions GmbH entwickelt. Wissenschaftliche Grundlage der Intervention war eine intensive Literaturrecherche zu psychosozialen Bedingungsfaktoren von Übergewicht und Adipositas, sowie die Arbeit mit Fokusgruppen und ExpertInnen aus Forschung und Praxis im Bereich der Adipositastherapie, deren Aussagen qualitativ ausgewertet wurden. Darüber hinaus wurde zur Qualitätssicherung im Verlauf der Studie ein Steering-Committee bestehend aus ExpertInnen im Bereich der Adipositasbehandlung und digitalen Gesundheitsversorgung einberufen. In der zweiten Studienphase von Dezember 2019 bis Dezember 2021 wurde die Effektivität der Intervention im Rahmen einer randomisiert-kontrollierten Studie (RCTs) im Wartegruppendesign untersucht. Der Interventionsarm erhielt dabei

die 12-wöchige App-basierte Intervention, wohingegen der Kontrollarm eine leere App erhielt. Über einen Zeitraum von 15 Monaten hinweg gab es vier Erhebungszeitpunkte: vor Beginn der Intervention (Eingangserhebung), nach Beendigung der 12-wöchigen Intervention (Nacherhebung), 6 Monate nach Beendigung der Intervention (Katamnese 1) und 12 Monate nach Beendigung der Intervention (Katamnese 2). Zu den jeweiligen Messzeitpunkten nahmen die Teilnehmenden an einer Onlinefragebogenstudie teil. Der Gewichtsverlauf wurde mithilfe des BMIs als Quotient des Gewichts in kg und der Körperhöhe in m^2 dokumentiert. Das Nutzungsverhalten der Teilnehmenden des Interventionsarms wurde über die App erfasst. Erst nach der letzten Erhebung, erhielten die Teilnehmenden des Kontrollarms Zugang zur Intervention.

2.3 Rekrutierung

Im August 2019 startete das Screening erster Studieninteressierter parallel zur Finalisierung der Appintervention. Eine Übersicht über die Ein- und Ausschlusskriterien für die Studienteilnahme sind Tabelle 2 zu entnehmen.

Tabelle 2: Ein- und Ausschlusskriterien des I-GENDO Projektes

Einschlusskriterien	Ausschlusskriterien
Volljährigkeit (≥ 18 Jahre)	Adipositas Grad III (BMI: > 39.9 kg/m²)
Übergewicht mit gewichtsassoziierten gesundheitlichen Problemen und/oder Ansammlung von viszeralem Fettgewebe und/oder hoher psychosozialer gewichtsassoziierter Disstress und aktuellem Wunsch Gewicht zu reduzieren	Aktuelle (oder innerhalb der letzten 12 Monate) Teilnahme an einem strukturierten Gewichtsreduktionsprogramm.
Adipositas Grad I oder II und subjektiven gewichtsassoziierten Einschränkungen und aktuellem Wunsch Gewicht zu reduzieren	Insulin-pflichtiger Diabetes Typ I
	Frühere oder geplante bariatrische Operation
	Aktuelle psychotherapeutische Behandlung gewichtsassoziierter Gesundheitsprobleme
	Gewichtsfördernde Medikamente
	Gewichtsreduzierende Medikamente
	Gewichtsfördernde Erkrankungen, die nicht umfassend behandelt wurden.
	Krebserkrankung in den vergangenen fünf Jahren
	Aktuelle Substanzabhängigkeit, Major Depression, Psychose oder akute Suizidalität oder Schwangerschaft.
	Ausgeprägte kognitive Beeinträchtigung
	Unzureichende Kenntnisse der Deutschen Sprache
	Binge-Eating-Störung
	Bulimia Nervosa

N= 675 Studieninteressierte wurden hinsichtlich der Eignung zur Studienteilnahme ausgehend von den Ein- und Ausschlusskriterien des Projektes untersucht (siehe Abb. 3). Im Dezember 2019 fand der erste Einschluss in die Studie statt, der letzte Einschluss im August 2020. Insgesamt wurden N= 213 Menschen mit Übergewicht und Adipositas Grad I und II eingeschlossen, davon N= 143 Frauen (67.1%).

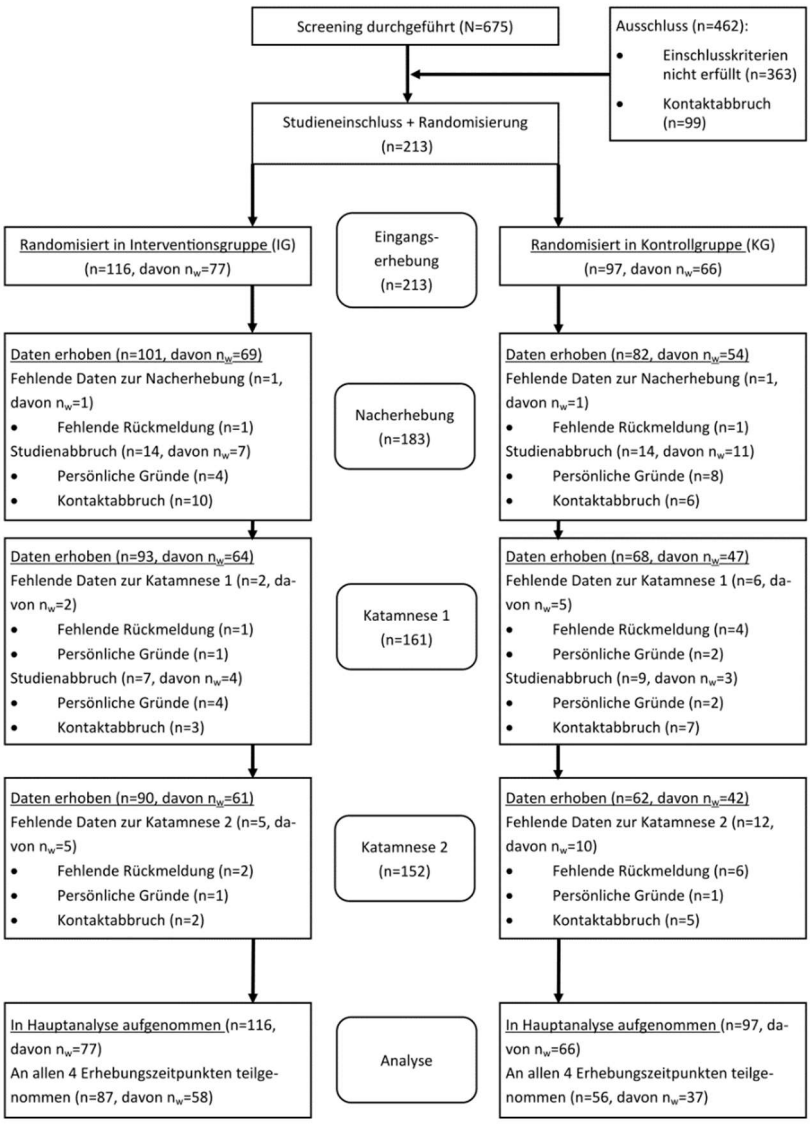

Abbildung 3: Flowchart der Rekrutierung und der Erhebungszeitpunkte des I-GENDO Projektes

2.4 Datengrundlage und Ziele der Originalarbeiten

Die erste Originalarbeit befasst sich mit der Entwicklung und der Gestaltung der mHealth Intervention. Basierend auf Daten aus dem Interventionsarm des RCTs zum Zeitpunkt der Eingangs- und Nacherhebung (siehe Abb. 3) wird die Verteilung der Tailoringelemente (**H1a und H1b**) untersucht, sowie die Adhärenz und Zufriedenheit mit der Intervention analysiert (**H2**).

In der zweiten Originalarbeit werden die Effektivität und Nachhaltigkeit der mHealth Intervention in Hinblick auf das emotionale, restriktive und externale Essverhalten, sowie auf den Gewichtsverlauf untersucht (**H3a, H3b, H3c, H4**). Grundlage zur Beurteilung sind Daten des Interventions- und

Kontrollarms zu allen vier Messzeitpunkten (Eingangserhebung, Nacherhebung, Katamnese 1 und Katamnese 2) (siehe Abb. 3).

In der dritten Originalarbeit wird FA in der vorliegenden Stichprobe von Menschen mit Übergewicht und Adipositas untersucht, bei denen keine Essstörung vorliegt (**H5a**). Zusätzlich werden Zusammenhänge von FA mit psychosozialen Faktoren, dysfunktionalem Essverhalten und Übergewicht und Adipositas untersucht (**H5b**). Grundlage zur Beurteilung sind Daten aus der Gesamtstichprobe zur Eingangserhebung (siehe Abb. 3).

3. Persönlicher Beitrag zu den Originalarbeiten

Die vorliegende Dissertation besteht aus drei Originalarbeiten, an deren Erarbeitung und Publikation die Autorin Magdalena Pape in Zusammenarbeit mit den genannten Ko-AutorInnen beteiligt war. Zum Zeitpunkt der Einreichung der Dissertation waren die Originalarbeiten 1 und 3 in englischsprachigen peer-review Fachzeitschriften open access bereits veröffentlicht worden. Die Originalarbeit 2 war zum Zeitpunkt der Einreichung der Dissertation bei einer englischsprachigen peer-review Fachzeitschrift zur open-access Publikation eingereicht („submitted“). Magdalena Pape war an der Entwicklung der mHealth Intervention beteiligt, sowie für die Rekrutierung Studienteilnehmenden, die Durchführung der Erhebungen und Datenaufbereitung und -analyse am Standort Bochum zu allen vier Messzeitpunkten verantwortlich. Für die Originalarbeiten 1 und 3 entwickelte sie Hypothesen, wertete die über die App und über die Onlinebefragung generierten Daten der Studienteilnehmenden aus und verfasste die Manuskripte unter der Supervision der Studienleitenden Prof. Dr. Sabine Steins-Löber, Prof. Dr. Jörg Wolstein und Prof. Dr. Stephan Herpertz. Als Zweitautorin war sie an der Hypothesenbildung, Datenanalyse und Interpretation der Ergebnisse der Originalarbeit 2 beteiligt. Zudem trug sie zur Verfassung des Manuskript-Entwurfes bei. Die Originalarbeiten befinden sich im Anhang der vorliegenden Dissertation. Magdalena Pape ist für alle weiteren Teile dieser Dissertation verantwortlich.

4. Ergebnisse und Diskussion der Originalarbeiten

4.1 A Tailored Gender-Sensitive mHealth Weight-Loss Intervention (I-GENDO): Development and Process Evaluation

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Der Artikel befindet sich in Anhang A

Es wurde eine modulare App-basierte mhealth Intervention entwickelt, welche psychologische Bedingungsfaktoren von Adipositas und Übergewicht individuell bearbeitete und dabei einen gendersensiblen Ansatz verfolgte. Innerhalb der 12-wöchigen Intervention wurden drei von fünf entwickelten Schwerpunktmodulen jeweils drei Wochen lang bearbeitet. Die beiden übrigen Module wurden in Form von Minimodulen in der zehnten Woche bearbeitet. Zudem gab es ein allgemeines Einführungs- (Woche 1) und Abschlussmodul (Woche 12). Die individuelle Zuordnung der Schwerpunktmodule erfolgte mithilfe eines Fragebogens, der vor Beginn der Intervention von den Studienteilnehmenden ausgefüllt wurde. Der revidierte Illness Perception Questionnaire (IPQ-R, (Moss-Morris et al., 2002) misst individuelle Krankheitsrepräsentationen bzw. Ursachenzuschreibungen der Teilnehmenden und wurde für Adipositas und Übergewicht adaptiert (Beispielitem: „Wenn ich über mein Übergewicht nachdenke, fühle ich mich deprimiert.“). Die 32 Items wurden auf einer fünfstufigen Likert-Skala von 1 („stimme überhaupt nicht zu“) bis 5 („stimme voll und ganz zu“) bewertet. Die Skalen des Fragebogens wurden neugeneriert und den fünf Schwerpunktmodulen der mHealth Intervention zugeordnet, wobei höhere Mittelwerte eine stärkere Beeinträchtigung in den jeweiligen Domänen repräsentierten. Das Stressmodul fokussierte auf stressinduziertem Essverhalten und einer Verbesserung von funktionalen

Stressregulationsmaßnahmen. Das Emotionsmodul bearbeitete Emotionen, die im Zusammenhang mit Übergewicht und Adipositas stehen, sowie emotionales Essverhalten. Das Konsequenzenmodul fokussierte auf die Folgen von Übergewicht und Adipositas, insbesondere die Erfahrung von gewichtsbezogener Diskriminierung und den Umgang damit. Das Kontrollmodul beschäftigte sich mit Defiziten in der nahrungsbezogenen Inhibitionsfähigkeit in Form von Essanfällen und externalem Essverhalten. Das Selbstwirksamkeitsmodul fokussierte auf die Stärkung der ernährungs- und bewegungsspezifischen Selbstwirksamkeit der Teilnehmenden. Neben diesem individuell psychologischen Ansatz, sollten auch geschlechtsspezifische Aspekte von Übergewicht und Adipositas in der Intervention berücksichtigt werden, um die Akzeptanz und Effektivität zu steigern. Dafür wurden für jedes der insgesamt sieben Module (drei Schwerpunktmodule, zwei Minimodule und das Einführungs- und Abschlussmodul) zwei geschlechtsadaptierte Versionen entworfen: eine Version, welche der bisherigen Evidenz folgend eher auf weibliche Aspekte von Übergewicht zugeschnitten war und eine, welche eher auf männliche Aspekte zugeschnitten war. Das Ziel der Studie war es einen gendersensiblen, statt geschlechtsbasierten dichotomen Ansatz zu verfolgen. Daher wurden die Varianten der Module nicht dem biologischen Geschlecht entsprechend zugewiesen, sondern jede/r der Teilnehmenden erhielt vor jedem Modul eine kurze Vorstellung der beiden Varianten und konnte davon selbstständig eine auswählen. Dabei wurden die Versionen nicht als gendersensibel, sondern entsprechend ihrer Inhalte vorgestellt. Abbildung 4 zeigt eine Übersicht über die Modulstruktur. Dem Anhang der Originalarbeit 1 sind detaillierte Informationen über die (gendersensible) Gestaltung der Module zu entnehmen.

Abbildung 4: Modulstruktur der Intervention. Computer-basiertes Tailoring: drei der fünf Schwerpunktmodule anhand des IPQ-R zugewiesen. Selbstständiges Tailoring: gendersensible Inhalte zu jedem Modul.

N = 116 (66.4 % weibliche) Teilnehmende wurden bei Einschluss in die Studie in die Interventionsgruppe randomisiert. Sie waren durchschnittlich 47.28 Jahre alt (SD = 11.66) und hatten einen mittleren BMI von 33.58 kg/m² (SD = 3.79).

4.1.1 Individualisierung der mHealth Intervention

Die meisten Teilnehmenden (N = 105, 90.5 %) haben das Kontrollmodul zugeordnet bekommen haben. Das Ergebnis ist im Einklang mit anderen Veröffentlichungen, die darauf hinweisen, dass Übergewicht und Adipositas in der Regel mit einer geringeren nahrungsbezogenen Inhibitionsfähigkeit verbunden ist (Duraccio et al., 2019; Houben et al., 2014; Liu et al., 2020). Signifikant mehr Frauen (N = 59, 77 %), als Männer (N = 22, 56 %) haben das Emotionsmodul zugeordnet bekommen, $\chi^2(1) = 4.11$, $p = .043$, $\varphi = .21$. Menschen mit stark ausgeprägtem emotionalem Essverhalten haben Probleme zwischen physiologischem Appetit und Essen als Emotionsregulationsmechanismus zu unterscheiden (Bruch, 1964). In der Folge ist emotionales Essverhalten mit einem erhöhten Konsum zuckerhaltiger Nahrungsmittel, einem höheren BMI und erhöhter Depressivität verbunden (Konttinen et al., 2010). Wie bereits oben beschrieben, deuten Studien darauf hin, dass mehr Frauen als Männer unter emotionalem Essverhalten leiden und ihr Übergewicht häufiger in Zusammenhang mit negativen Gefühlen erklären (Henning et al., 2022; Larsen et al., 2006). Das Stressmodul wurde 65.5 % und das Selbstwirksamkeitsmodul 47.4 % der Teilnehmenden zugewiesen. Ungefähr ein Viertel (25.9 %) der Teilnehmenden hat das Konsequenzenmodul zugewiesen bekommen, in welchem der Umgang mit negativen Folgen des

Übergewichts, vor allem auch der Erfahrung gewichtsbezogener Diskriminierung, bearbeitet wurde. In einer repräsentativen deutschen Stichprobe wurde die Prävalenz der Erfahrung von gewichtsbezogener Diskriminierung bei Menschen mit Adipositas Grad I und II zwischen 10.2 % und 18.7 % beschrieben (Sikorski et al., 2016). Dass in der vorliegenden Studie rund 26 % der Teilnehmenden das Konsequenzenmodul zugewiesen bekommen haben, könnte ein Hinweis darauf sein, dass es sich hier um eine besonders vulnerable Stichprobe handelt, die vielleicht gerade wegen der Erfahrung gewichtsbezogener Diskriminierung eine psychologische Intervention einer Lifestyle-Intervention vorziehen. Obwohl die Ergebnisse der oben genannten Studie darauf hinweisen, dass mehr Frauen als Männer Erfahrungen mit gewichtsbezogener Diskriminierung berichten, zeigten sich in der vorliegenden Studie keine signifikanten Geschlechtsunterschiede in der Zuweisung des Konsequenzenmoduls.

Ebenso zeigte sich eine heterogene Auswahl der geschlechtsadaptierten Varianten sowohl bei männlichen, als auch weiblichen Teilnehmenden, wobei insgesamt häufiger die „weibliche“ Variante (58.2 % der Entscheidungen) ausgewählt wurde. Entgegen eines binären Geschlechtsverständnisses haben die Teilnehmenden demnach nicht durchweg geschlechtskonform die Modulvarianten ausgewählt. Unsere Ergebnisse unterstützen daher eine gendersensible Sichtweise auch in der Psychologie (Hyde et al., 2019).

Wie bereits oben beschrieben, empfiehlt die interdisziplinäre S3-Leitlinie zur *Prävention und Therapie der Adipositas*, dass Menschen mit Adipositas eine individualisierte und evidenzbasierte Therapie angeboten werden sollte, welche sich an den persönlichen Umständen der Betroffenen orientieren sollte (Hauner et al., 2014). Aufgrund der heterogenen Verteilung der computer-basierten (**H1a**) und selbstständigen Tailoringelemente (**H1b**), kann geschlussfolgert werden, dass die hier vorgestellte mHealth Intervention individualisiert genutzt werden konnte.

4.1.2 Nutzung und Zufriedenheit mit der mHealth Intervention

Im Verlauf der 12-wöchigen Intervention konnte eine Abnahme der Nutzungsfrequenz und –dauer festgestellt werden. Reduktionen des Nutzungsverhaltens sind auch aus anderen Appinterventionsstudien bekannt, vor allem aus solchen mit langen Interventionszeiträumen (Butryn et al., 2020; Signal et al., 2020). Dabei kann eine Vielzahl an Gründen für die verhältnismäßig geringere Adhärenz zu internetbasierten Interventionen vermutet werden, darunter in Bezug auf die vorliegende Studie die hohe Anzahl an konkurrierenden kommerziellen „Abnehmapps“, sowie die hohe psychische Belastung im Zuge der COVID-19 Pandemie (Bühlmeier et al., 2022; Eysenbach, 2005). Bei der vorliegenden Stichprobe fand die Reduktion jedoch vor allem innerhalb der ersten drei Wochen statt, während sich die Nutzungsmaße anschließend nahezu einpendelten. Die weiblichen Teilnehmenden haben die App insgesamt regelmäßiger (M = 96.51 Aktionen mit der App, SD = 88.03) und intensiver (M = 624.85 Minuten, SD = 427.94) genutzt, als die männlichen Teilnehmenden, welche durchschnittlich 55.89 Aktionen (SD = 45.62) mit der App durchführten und diese 346.69 Minuten (SD = 285.68) lang nutzten. Dies könnte darauf zurückzuführen sein, dass Frauen im Durchschnitt mehr Zeit am Smartphone verbringen, und sich stärker für gesundheitliche Aspekte und Selbstfürsorge interessieren (Andone et al., 2016; Escoffery, 2018; Smail-Crevier et al., 2019). Ein tiefgehender Vergleich mit früheren Studien ist jedoch erschwert, da die bisherige Evidenzlage zu Geschlechtsunterschieden in der Adhärenz zu mHealth Interventionen wenig valide ist. In vielen Studien wurden gar keine Geschlechtsunterschiede untersucht, oder Datengrundlage waren Stichproben mit über 90 % Frauenanteil (Milne-Ives et al., 2020).

Insgesamt waren 83 % der Teilnehmenden adhärent mit der Intervention (mindestens 12 Aktionen mit der App, mindestens 120 Minuten Nutzung der App). Wie im Folgenden beschrieben wird, ist der Vergleich der berichteten Adhärenz mit der aus vergleichbaren Studien, leider erschwert. Signal et al. (2020) entwickelten eine mHealth Intervention zur Selbstbeobachtung bei (Prä-) Diabetes und berichteten eine Adhärenz (Anzahl an Teilnehmenden, die mindestens einmal die App nutzten) von 74 %. Mithilfe der APPetite-App (Ruf et al., 2021) können Bewegungs- und Ernährungsdaten erfasst

und im Zusammenhang mit zufällig erfragten psychologischen Parametern (bspw. Affekt, Stress) analysiert werden. Die Adhärenz wurde definiert als der Prozentsatz an Rückmeldungen zu den Benachrichtigungen der App und lag bei 80 %. Die ImpulsePal-App fokussiert auf eine Reduktion von impulsivem Essverhalten (van Beurden et al., 2019). In der begleitenden Studie wurde die Adhärenz als Anzahl an Datensätzen zum 3-Monats Katamnesezeitpunkt mit 76 % beschrieben.
Nach Beendigung der Appintervention, wurden die Teilnehmenden nach ihrer Zufriedenheit mit der Intervention befragt. N = 41 Studienteilnehmende bewerteten die App und berichteten eine hohe Gesamtzufriedenheit (86 %). Die Benutzerfreundlichkeit der App wurde mit 71 % zufriedenstellend beurteilt.

Mit einer Adhärenz von 83 %, einer Zufriedenheit von 86 % und einer Bewertung der Benutzerfreundlichkeit der mHealth Intervention von 71 %, kann die Nutzung und Zufriedenheit der App insgesamt als zufriedenstellend hoch bewertet werden (**H2**).

4.1.3 Zusammenfassung und Limitationen

Die mHealth Intervention konnte individualisiert genutzt werden, zudem waren die Nutzungsmaße und die Zufriedenheit mit der Intervention zufriedenstellend. Dabei zeigten sich Geschlechtsunterschiede in der Nutzungsdauer und -intensität der App. Die weiblichen Teilnehmenden haben die App insgesamt häufiger und länger genutzt, als die männlichen Teilnehmenden. Gleichzeitig haben sowohl die männlichen, als auch die weiblichen Teilnehmenden vermehrt die Modulversionen gewählt, die der bisherigen Evidenz folgend eher weibliche Aspekte von Übergewicht und Adipositas bearbeitet haben. In der Gestaltung der mHealth Intervention wurde ein innovativer gendersensibler Ansatz verfolgt, bei dem geschlechtsadaptierte Modulversionen gestaltet wurden, diese jedoch nicht computer-basiert nach dem biologischen Geschlecht zugewiesen wurden (sprich die männlichen Teilnehmenden erhalten die männlich-adaptierte Version, die weiblichen die weiblich-adaptierten). Vielmehr wurden zu Beginn jedes Moduls zwei Versionen der

Module dargestellt, aus denen die Teilnehmenden wählen konnten. Da die Teilnehmenden nicht darüber informiert wurden, dass es sich um geschlechtsadaptierte Versionen handelte, müssen keine verzerrenden Effekte durch soziale Erwünschtheit oder Rollenbilder vermutet werden. Es ist jedoch möglich, dass die Beschreibungen der Versionen nicht valide waren, was ferner überprüft werden sollte. Darüber hinaus bestand das Arbeitsteam, das an der Gestaltung der App beteiligt war, primär aus weiblichen Forscherinnen, wodurch es zu einer Konfundierung in der Gestaltung der Versionen gekommen sein könnte. Für zukünftige Studien mit gendersensiblem Ansatz empfehlen wir daher bereits im Vorfeld konfundierende Einflüsse zu minimieren, indem es in den Teams bereits ausgeglichene Geschlechtsverhältnisse gibt.

Aufgrund der Heterogenität der Definitionen von Adhärenzmaßen ist eine Einordnung der Ergebnisse zur Adhärenz erschwert. In der vorliegenden Studie galten Teilnehmende als adhärent, wenn sie die App im Verlauf der 12-wöchigen Intervention mindestens 12 Mal und insgesamt mindestens 120 Min nutzten. Die Definition erfolgte basierend auf der Annahme, dass die Bearbeitung einer Übung im Durchschnitt 10 min in Anspruch nehmen würde, wodurch ein adhärenter Nutzer durchschnittlich mindestens eine Übung pro Woche absolviert haben müsste, um einen Effekt der Intervention erwarten zu können. Das Adhärenzmaß ist damit wohl konservativer, als in Studien, die Adhärenz über die einmalige Nutzung definierten (Signal et al., 2020), aber auch liberaler, als in Studien, die Adhärenz in % der möglichen Aktionen mit der App definierten (Ruf et al., 2021). Zukünftige Studien sollten zur Vergleichbarkeit der Ergebnisse einheitliche Definitionen entwickeln. Die Gesamtbewertung der App war hoch (86 %), jedoch nahmen nur N = 41 Teilnehmende an der freiwilligen Bewertung über die App teil. Es kann vermutet werden, dass nur diese die App bis zum Schluss nutzten und es daher eine Verzerrung in Richtung einer höheren Zufriedenheit geben könnte.

4.2 Differential Effects of the Individualized Gender-Sensitive mHealth Intervention I-GENDO on Eating Styles in Individuals with Overweight and Obesity – A Randomized Controlled Trial

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Der Artikel befindet sich in Anhang B

Um die Effektivität der mHealth Intervention in Hinblick auf das Essverhalten und den Gewichtsverlauf zu untersuchen, wurden Daten der oben genannten N = 116 Teilnehmenden der Interventionsgruppe (IG) mit denen der N = 97 Teilnehmenden der Kontrollgruppe (KG) zu allen vier Messzeitpunkten verglichen: vor Beginn der Intervention (Eingangserhebung), nach Beendigung der 12-wöchigen Intervention (Nacherhebung), 6 Monate nach Beendigung der Intervention (Katamnese 1) und 12 Monate nach Beendigung der Intervention (Katamnese 2). Das Essverhalten wurde mithilfe des Dutch Eating Behaviour Questionnaires (DEBQ, Nagl et al., 2016; Van Strien et al., 1986) auf den Domänen 1. Emotionales Essverhalten, 2. Restriktives Essverhalten und 3. Externales Essverhalten, untersucht. Der Gewichtsverlauf wurde mithilfe des BMIs als Quotient des Gewichts in kg und der Körperhöhe in m² dokumentiert. Es wurde für jede der Zielvariablen eine Mehrebenenanalyse durchgeführt um den Einfluss der Gruppe (0= KG, 1= IG), der Zeit (0= Eingangserhebung, 1= Nacherhebung, 2= Katamnese 1 und 3= Katamnese 2), und des Geschlechts (0 = weiblich, 1= männlich) zu untersuchen, sowie die Interaktionseffekte. Das allgemeine Signifikanzniveau wurde a-priori auf $p <. 05$ gesetzt. Für die Interaktionseffekte wurde ein *p*-Wert

von < .10 als statistisch signifikant definiert.

Zum Zeitpunkt der Eingangserhebung zeigten sich keine Gruppenunterschiede zwischen den Zielvariablen. Jedoch waren die weiblichen Teilnehmenden der KG jünger, als die männlichen Teilnehmenden ($F(1, 209) = 7.07$, $p = .008$, partielles $\eta^2 = .033$). Zudem berichteten die weiblichen Teilnehmenden beider Gruppen zum Zeitpunkt der Eingangserhebung höhere Werte im emotionalen Essverhalten, als die männlichen Teilnehmenden ($F(1, 209) = 14.40$, $p < .001$, partielles $\eta^2 = .064$).

4.2.1 Effektivität in Bezug auf das emotionale Essverhalten

Zum Zeitpunkt der Katamnese 1 berichteten die weiblichen Teilnehmenden der IG signifikant geringere Werte im emotionalen Essverhalten, als die weiblichen Teilnehmenden der KG (Differenz: 0.28 Punkte, 95 % CI: 0.20, 0.36). Dieser Effekt war zum Zeitpunkt der Nacherhebung und Katamnese 2 nicht signifikant. Vom Zeitpunkt der Eingangserhebung bis zum Zeitpunkt der Katamnese 2 Messung reduzierten die weiblichen Teilnehmenden der IG das emotionale Essverhalten von 3.3 auf 3.0 Punkte, was einer Verbesserung vom 85 zum 80 Perzentilrang innerhalb der Teilnehmenden mit Adipositas, und einer Verbesserung vom 95 zum 90 Perzentilrang innerhalb der weiblichen Teilnehmenden der Normstichprobe entspricht (Nagl et al., 2016). Bei den männlichen Teilnehmenden konnten zu keinem Zeitpunkt signifikante Gruppenunterschiede festgestellt werden, woraus sich schließen lässt, dass die Intervention bei männlichen Teilnehmenden keinen Einfluss auf das emotionale Essverhalten ausgeübt hat. Ein möglicher Grund dafür könnte darin liegen, dass die weiblichen Teilnehmenden bereits zum Zeitpunkt der Eingangserhebung höhere Werte aufwiesen, als die männlichen Teilnehmenden. Wie bereits zuvor beschrieben, deuten vorherige Studien darauf hin, dass Frauen häufiger unter emotionalem Essverhalten leiden und negative Gefühle häufiger als Ursache und aufrechterhaltenden Faktor ihres Gewichts betrachten, als Männer (Henning et al., 2022; Larsen et al., 2006). In unserer Studie haben mehr weibliche Teilnehmende das Emotionsmodul als Schwerpunktmodul zugeordnet bekommen (siehe Kap. 4.1), somit also auch fokussierter am emotionalen Essverhalten gearbeitet, als die männlichen Teilnehmenden, was den Effekt ebenfalls

erklären könnte. Auch in der deutschen Validierungsstudie des DEBQ wird ein höheres emotionales Essverhalten mit Übergewicht und Adipositas, sowie mit dem weiblichen Geschlecht in Zusammenhang gebracht (Nagl et al., 2016).

4.2.2 Effektivität in Bezug auf das externale Essverhalten

Sowohl bei den männlichen, als auch bei den weiblichen Teilnehmenden übte die Intervention jedoch einen Effekt auf das externale Essverhalten aus. So berichteten die weiblichen Teilnehmenden der IG zum Zeitpunkt der Nacherhebung (Differenz: -0.20 Punkte, 95 % CI: -0.30, -0.10), der Katamnese 1 (Differenz: -0.29 Punkte, 95 % CI: -0.40, -0.19) und der Katamnese 2 (Differenz: -0.23 Punkte, 95 % CI: -0.34, -0.13) geringere Werte, als die weiblichen Teilnehmenden der KG. Die männlichen Teilnehmenden der IG berichteten nur zum Zeitpunkt der Nacherhebung geringere Werte, als die Teilnehmenden der KG (Differenz = -0.30 Punkte, 95 % CI: -0.45, -0.15).

Externales Essverhalten wird durch eine hohe Sensibilität gegenüber Nahrungsreizen, sowie eine geringe nahrungsbezogene Inhibitionsfähigkeit ausgelöst (siehe Kap. 1.5). Die Reduktion des externalen Essverhaltens in der vorliegenden Studie könnte darauf zurückzuführen sein, dass ein Großteil (> 90 %) der männlichen und weiblichen Teilnehmenden das Kontrollmodul als Schwerpunktmodul zugeordnet bekommen haben, welches auf eine Steigerung der nahrungsbezogenen Inhibitionsfähigkeit abzielt (siehe Kap. 4.1).

4.2.3 Effektivität in Bezug auf das restriktive Essverhalten

Zum Zeitpunkt der Katamnese 2 berichteten die Teilnehmenden der IG höhere Werte im restriktiven Essverhalten, als die Teilnehmenden der KG, $\beta = 0.23$, $p = .069$. Dieser Effekt zeigte sich bereits zum Zeitpunkt der Katamnese 1 ($\beta = 0.26$, $p = .033$) und zum Zeitpunkt der Nacherhebung ($\beta = 0.47$, $p < .001$). Obwohl der Effekt bis zum Zeitpunkt der Katamnese 2 signifikant blieb, so zeigte sich doch eine Verringerung des Gruppenunterschieds vom Zeitpunkt der Nacherhebung (Differenz: 0.28

Punkte) zur Katamnese 2 (Differenz: 0.13 Punkte). Eine Steigerung des restriktiven Essverhaltens gilt als positiver Prädiktor für einen erfolgreichen Gewichtsverlust bei Diäten (van Strien et al., 2009). Es zeigten sich keine Geschlechtsunterschiede in der Effektivität der Intervention in Hinblick auf das restriktives Essverhalten, jedoch deskriptiv geringere Werte der männlichen Teilnehmenden zum Zeitpunkt der Eingangserhebung. In der deutschen Validierungsstudie des DEBQ werden statistisch signifikante Geschlechtsunterschiede berichtet, insofern als dass Frauen stärkeres restriktives Essverhalten berichten, als Männer (Nagl et al., 2016). Dies wird darauf zurückgeführt, dass Frauen häufiger Diät halten und in unserer Gesellschaft ein schlankeres Frauenbild idealisiert wird (Kiefer et al., 2005). Bei der vorliegenden Stichprobe handelt es sich um Betroffene, die psychologische Unterstützung im Abnehmprozess suchten, weswegen vermutet werden kann, dass sowohl die männlichen, als auch die weiblichen Teilnehmenden zuvor mehrfach erfolglose Diätversuche absolviert hatten. Dies könnte erklären, warum in der vorliegenden Stichprobe keine Geschlechtsunterschiede im restriktiven Essverhalten gefunden wurden.

4.2.4 Effektivität in Bezug auf das Gewicht

Die männlichen Teilnehmenden der IG konnten bis zum Zeitpunkt der Katamnese 2 signifikant nachhaltig Gewicht reduzieren (Differenz: -1.44 BMI Punkte, 95 % CI: -1.97, -0.91). Im Vergleich zur KG stieg dabei die gemittelte Differenz über die Messzeitpunkte Nacherhebung (Differenz: -0.84 BMI Punkte, 95 % CI: -1.35, 0.33) und Katamnese 1 (Differenz: -1.00 BMI Punkte, 95 % CI: -1.54, -0.47) an. Dabei zeigte sich eine Reduktion des BMIs von 33.2 kg/m² zum Zeitpunkt der Eingangserhebung auf 32.6 kg/m² zum Zeitpunkt der Nacherhebung, und einer langfristigen Reduktion bis zur Katamnese 2 bis auf 32.2 kg/m². Bei den weiblichen Teilnehmenden zeigte sich kein Effekt der Intervention auf den Gewichtsverlauf. Auch frühere Studien deuten darauf hin, dass wenngleich Männer insgesamt seltener an GRMs teilnehmen, sie im Falle einer Teilnahme stärker Gewicht reduzieren, als weibliche Teilnehmende (Chin et al., 2016; Cooper et al., 2021). Die weiblichen Teilnehmenden der IG haben jedoch die App länger und intensiver genutzt, als die

männlichen Teilnehmenden (siehe Kap. 4.1). Dieses Ergebnis steht demnach im Widerspruch zu der Annahme, dass eine höhere Adhärenz mit Interventionen mit einem besseren Outcome im Zusammenhang stünde (Acharya et al., 2009; Jacobs et al., 2017).

4.2.5 Zusammenfassung und Limitationen

In Hinblick auf die Effektivität der mHealth Intervention zeigten sich gemischte Effekte (**H3 und H4**). Das Ziel der mHealth Intervention war es dysfunktionales Essverhalten, welches ein wesentlicher Faktor in der Genese und Aufrechterhaltung von Übergewicht und Adipositas ist, durch die Bearbeitung zugrundliegender psychosozialer Faktoren, zu verbessern. Es zeigten sich stärkere und nachhaltige Effekte der Intervention auf das dysfunktionale Essverhalten der weiblichen Teilnehmenden, wohingegen die männlichen Teilnehmenden kurz- und langfristig erfolgreich Gewicht reduzieren konnten. Entsprechend der Hypothesen, konnten die weiblichen Teilnehmenden im Zuge der Intervention das externale Essverhalten nachhaltig verringern (**H3b**) und das restriktive erhöhen (**H3c**). Wobei auch die männlichen Teilnehmenden nachhaltig das restriktive Essverhalten verbessern konnten (**H3c**). Dieser Effekt kann als Erfolg der Intervention betrachtetet werden, da vergleichbare Studien bisher nur kurzfristige Verbesserung im restriktiven Essverhalten erreichen konnten (Bijlholt et al., 2021). Eine Steigerung des restriktiven Essverhaltens in Kombination mit einer Verringerung des emotionalen Essverhaltens, gilt als positiver Prädiktor für einen erfolgreichen Gewichtsverlust (van Strien et al., 2009). Die Intervention hat jedoch bei männlichen Teilnehmenden keinen und bei weiblichen Teilnehmenden nur einen kurzfristigen Effekt auf das emotionale Essverhalten ausgeübt (**H3a**). Dabei könnte die kurzfristige Verbesserung bei den weiblichen Teilnehmenden darauf zurückzuführen sein, dass mehr weibliche Teilnehmende das Emotionsmodul zugeordnet bekommen haben. Vorherige Studien zeigen, dass psychotherapeutisch ausgerichtete mHealth Interventionen einen Effekt auch auf tieferliegende emotionale Prozesse, sowie Grübelneigung, bei PatientInnen mit Depressionen oder Angststörungen ausüben können (Cook et al., 2019; Firth et al., 2017; Firth et al., 2017). Die nicht zufriedenstellenden Effekte der I-GENDO

mHealth Intervention auf das emotionale Essverhalten müssen demnach genau analysiert werden, das Emotionsmodul ggf. überarbeitet werden. Es sei jedoch auch angemerkt, dass die durchgeführte Erhebung von Dezember 2019 bis Dezember 2021 und damit inmitten der COVID-19 Pandemie durchgeführt wurde. Im Zuge der Pandemie kam es nicht nur zu einer allgemeinen Verstärkung depressiver Symptome, sondern auch zu einer Steigerung des emotionalen Essverhaltens im Zuge der zunehmenden Belastung (Burnatowska et al., 2022). Durch die Restriktionen im Rahmen der Pandemie waren darüber hinaus Sporteinrichtungen, wie Fitnessstudios und Vereine, geschlossen. Zur Erreichung einer negativen Energiebilanz spielt auch das Bewegungsverhalten von Betroffenen eine wesentliche Rolle (siehe Kapitel 1.3). Der ausbleibende Effekt auf das Gewicht der weiblichen Teilnehmenden, sowie nur geringe Effekte auf das Gewicht der männlichen Teilnehmenden, könnte zumindest teilweise über eine Reduktion des Bewegungsverhaltens Im Zuge der Pandemie erklärt werden.

4.3 Food Addiction and Its Relationship to Weight- and Addiction-Related Psychological Parameters in Individuals With Overweight and Obesity

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Der Artikel befindet sich im Anhang C

In der vorliegenden Originalarbeit wurde FA in einer Stichprobe von Menschen mit Adipositas und Übergewicht untersucht, bei denen im Vorfeld diagnostisch das Vorliegen einer BES oder BN ausgeschlossen wurden (siehe Tabelle 2, Kapitel 2.3). Zum Ausschluss einer BES oder BN wurde ein zweistufiges Verfahren angewendet, bei dem Studieninteressierte zunächst einen Screeningfragebogen (Munich ED-Quest; Fichter et al., 2015) ausgefüllt haben. Im Falle eines positiven Screenings wurde eine ausführliche Diagnostik basierend auf dem Eating Disorder Examination-Questionnaire (Hilbert & Tuschen-Caffier, 2016) durchgeführt. Es wurden Daten der Gesamtstichprobe N= 213 (67.1% weiblich) zum Zeitpunkt der Eingangserhebung im Querschnitt analysiert.

Die Teilnehmenden hatten einen mittleren BMI von 33.35 kg/m² (SD = 3.79). Untersucht wurde die Prävalenz und Symptomschwere von FA mithilfe der deutschen Version der YFAS II (Gearhardt et al., 2016; Meule et al., 2017) (siehe auch Kapitel 1.4.1). Darüber hinaus wurden die folgenden Maße erhoben: Depressivität (PHQ-9, Löwe et al., 2002), pathologischer Alkoholkonsum (AUDIT, Dybek et al., 2006; Saunders et al., 1993), Internetbezogene Störungen (AICA-S, Wölfling et al., 2016), allgemeine Psychopathologie (BSI-18, Derogatis & Fitzpatrick, 2004; Spitzer et al., 2011), Impulsivität (BIS-15, Meule et al., 2011), impulsives Essverhalten (Pudel & Westenhöfer, 1989),

emotionales Essverhalten (DEBQ, (Nagl et al., 2016; Van Strien et al., 1986), NGS (WBIS, Hilbert et al., 2014) und allgemeine Selbstwirksamkeit (SWE, Jerusalem & Schwarzer, 2003). Darüber hinaus wurde die nahrungsbezogene Inhibitionsfähigkeit mithilfe eines selbstkonzipierten Fragebogens (FRIS, unveröffentlicht) auf 4 Faktoren untersucht: 1. Entzugshandlungen (action withdrawal, AW), bspw. zwischen den Mahlzeiten essen, 2. Handlungsstopp (action cancelation, AC), bspw. trotz Völlegefühl weiteressen, 3. Belohnungssensibilität (reward sensitivity, RS), bspw. Nahrung wird als sehr belohnend wahrgenommen, 4. Handlungsaufschub (delay discouting, DD), bspw. sofort essen, wenn Drang verspürt wird.

4.3.1 Prävalenz von FA in der Stichprobe

Die Prävalenz von FA in der Stichprobe betrug 15 % (N = 32/213), mit höheren, aber nicht statistisch signifikanten Prävalenzen bei weiblichen (18.2 %, N = 26/143) im Vergleich zu männlichen Teilnehmenden (8.6 %, N = 6/70). Die Ergebnisse stimmen mit vorherigen Untersuchungen überein, die zeigten, dass FA bei Menschen mit Übergewicht und Adipositas häufiger vorkommt (17.2 %), als in der Normalbevölkerung (7.9 %) (Hauck et al., 2017; Pursey et al., 2014). In Stichproben mit Teilnehmenden an GRMs, bei denen das Vorhandensein anderer Essstörungen nicht ausgeschlossen wurde, wurden höhere Prävalenzangaben gemacht (34.5 % bis 38 %) (Meule et al., 2015; Vidmar et al., 2021).

4.3.2 Zusammenhänge von FA mit psychosozialen Faktoren, dysfunktionalem Essverhalten und Gewicht

Die Gruppe der Teilnehmenden mit FA unterschied sich nicht signifikant von der Gruppe der Teilnehmenden ohne FA hinsichtlich soziodemographischer Maße und dem BMI. Entsprechend der Ergebnisse früherer Studien (Burmeister et al., 2013; Cassin et al., 2019; Gearhardt et al., 2014; Pedram et al., 2013), war die FA-Symptomschwere positiv mit einem erhöhten BMI (r = 0.17, p =

0.014) und negativ mit Selbstwirksamkeit assoziiert (r = −0.21, p = 0.002). Substanzkonsumstörungen und suchtartige Verhaltensweisen korrelieren meist hoch miteinander und es besteht eine hohe Gefahr der Suchtverschiebung zwischen den Störungsbildern (Chiappetta, 2022; Marmet et al., 2019). In unserer Studie korrelierte die FA-Symptomschwere mit Internetbezogenen Störungen (r = 0.18, p = 0.011). Dieser Sammelbegriff beschreibt die suchtartige Nutzung verschiedener Inhalte und Applikationen im Internet, bspw. Computerspiele, Glücksspiele, oder Pornografie. Menschen mit Internetbezogenen Störungen ernähren sich meist ungesünder und verbringen viel Zeit sitzend, wodurch die FA-Symptomatik wohl auch durch die Zunahme an Körpergewicht verstärkt werden kann (Vandelanotte et al., 2009; Yildirim et al., 2018). Betroffene mit Interbezogenen Störungen weisen meist Defizite in der Affektwahrnehmung und –regulation auf (Pape et al., 2022), welche auch im Zusammenhang mit FA stehen (Kircaburun et al., 2020).

Im Kontrast zu früheren Studien (C. Davis & Carter, 2009; García-García et al., 2014; Tinghino et al., 2020), zeigten sich jedoch in unserer Studie keine Zusammenhänge zwischen FA und pathologischem Alkoholkonsum (r = -0.09, p > .05). Dies könnte darauf zurückzuführen sein, dass Studieninteressierte bei Erfüllung der Kriterien einer Alkoholkonsumstörung im Vorfeld der Studienteilnahme diagnostisch ausgeschlossen wurden (siehe Tab. 2, Kap. 2.3). Obwohl jedoch auch Major Depression ein Ausschlusskriterium zur Studienteilnahme war, zeigten sich Zusammenhänge zwischen FA und Depressivität (r = 0.33, p < 0.001) und allgemeiner Psychopathologie (r = 0.35, p < 0.001). Diese Ergebnisse verdeutlichen den ausgeprägten Leidensdruck Betroffener, welcher zusätzlich zur Gewichtszunahme beitragen kann (Bourdier et al., 2018; Burmeister et al., 2013; Gearhardt et al., 2012). Es zeigten sich positive Korrelationen zwischen FA und emotionalem Essverhalten (r = 0.36, p < 0.001) und NGS (r = 0.44, p < 0.001). Teilnehmende mit FA berichteten höhere NGS (t(211) = 5.27, p < .001, d = 1.01) und stärker ausgeprägtes emotionales Essverhalten (t(211) = 4.01, p < .001, d = 0.71) im Vergleich zu Teilnehmenden ohne FA. Dabei kann ein Wechsel von positiver Verstärkung (Essen als Belohnung) zu negativer Verstärkung (Diät führt zu Entzugserscheinungen) vermutet werden, wodurch der belohnende Effekt vor allem zuckerreicher

Nahrungsmittel durch einen konditionierten stressreduzierenden Effekt weitgehend ersetzt wird (Parylak et al., 2011).

Darüber hinaus zeigten sich wie erwartet Korrelationen von suchtartigem Essverhalten mit impulsivem Essverhalten (r = 0.48, p < 0.001) und Defiziten auf allen vier Faktoren der nahrungsbezogenen Inhibitionsfähigkeit (AW: r = −49, p < 0.001; AC: r = −0.41, p < 0.001, RS: r = −0.46, p < 0.001; und DD: r = −0.27, p < 0.001). Jedoch zeigten sich keine signifikanten Unterschiede zwischen den Teilnehmenden mit FA und ohne FA hinsichtlich des Faktors DD (t(211) = 2.14, p > *.05*). Die beschriebenen Defizite im Bereich des Handlungsaufschubs (sprich einem Hungerreiz schnell nachzugeben) scheinen bei Menschen mit Übergewicht und Adipositas allgemein erhöht zu sein (Mole et al., 2015).

4.3.3 Zusammenfassung und Limitationen

Das Konzept FA ist wissenschaftlich umstritten, vor allem aufgrund der großen Überschneidungen der Symptomatik mit denen von anderen Essstörungen, vor allem der BES und der BN. Wie bereits in Kapitel 1.4.1 erwähnt gab es bisher keine Studien, die FA in einer Stichprobe von Betroffenen mit Übergewicht und Adipositas untersuchten, bei denen zuvor ausgeschlossen wurde, dass sie unter einer anderen Essstörung leiden. Im Rahmen der Rekrutierungsphase in der Studie wurde mithilfe von Screening-Fragebögen und standardisierten klinischen Interviewleitfäden das Vorliegen einer Essstörung diagnostisch ausgeschlossen. Dennoch zeigte sich eine FA-Prävalenz von 15 % innerhalb der Studienteilnehmenden (**H5a**). Dieses Ergebnis bestärkt die Sichtweise FA als eigenständiges Störungsbild zu betrachten (Gearhardt & Hebebrand, 2021). Darüber hinaus zeigten sich Zusammenhänge der FA Symptomschwere mit psychosozialen Faktoren, wie einer erhöhten NGS und eingeschränkten nahrungsbezogenen Inhibitionsfähigkeit, sowie mit dysfunktionalem Essverhalten und Übergewicht bzw. Adipositas (**H5b**). Die Subgruppe der Menschen mit FA unterscheidet sich in ihrer Komorbidität und dem psychischen Belastungsgrad signifikant von

Menschen mit Übergewicht und Adipositas, die nicht die Kriterien einer FA erfüllen. Als Limitation muss benannt werden, dass das Vorliegen einer BES und BN zwar mithilfe eines zweistufigen klinisch-strukturierten Diagnoseverfahrens ausgeschlossen wurde, die FA Diagnose jedoch basierend auf einem Fragebogen gestellt wurde. Für zukünftige Studien bedarf es der Entwicklung klinisch-standardisierter Diagnoseinstrumente für FA.

5. Gesamtdiskussion

Aufgrund der rasanten globalen Zunahme von Übergewicht und Adipositas, sowie den hohen Kosten für Gesundheitssysteme weltweit, bedarf es der Entwicklung und Beforschung innovativer und kosteneffizienter Therapien. Das Ziel der vorliegenden Dissertation war es, psychosoziale Faktoren von Übergewicht und Adipositas in der digitalen Adipositastherapie zu betrachten. Dafür wurden Untersuchungen zu zwei Fragestellungen durchgeführt (siehe Abb. 2, Kap. 1.7), deren Ergebnisse im Folgenden diskutiert werden. Dabei wird auch auf die Rolle von Geschlecht und Gender in den durchgeführten Untersuchungen und perspektivisch in der Psychotherapie eingegangen.
Die generierten Erkenntnisse werden anschließend in das Biopsychosoziale Modell von Übergewicht und Adipositas (siehe Abb. 1, Kap. 1.3) eingeordnet.

5.1 Effekt psychosozialer Faktoren von Übergewicht und Adipositas auf das Essverhalten und den Gewichtsverlauf

Das erste Ziel dieser Dissertation war es zu untersuchen, ob die Bearbeitung psychosozialer Faktoren von Übergewicht und Adipositas in der digitalen Adipositastherapie zu einer kurzfristigen und nachhaltigen Verbesserung des dysfunktionalen Essverhaltens und Gewichtsreduktion beitragen kann. Zur Beantwortung der Fragestellung wurde eine App-basierte mHealth Intervention entwickelt, die individualisiert und gendersensibel angeboten und genutzt werden konnte. Die Studienteilnehmenden waren ausreichend zufrieden mit der Intervention und ein Großteil (83 %) nutzte die App ausreichend regelmäßig und lange. Durch die Bearbeitung psychosozialer Faktoren von Übergewicht und Adipositas, zeigten sich Verbesserungen im dysfunktionalen Essverhalten, sowie eine geringfügige Reduktion des Ausgangsgewichtes. Die Effekte waren jedoch hinsichtlich ihrer Nachhaltigkeit gemischt, und es zeigten sich ferner Geschlechtsunterschiede. Es bedarf demnach der Überarbeitung und Überprüfung der genannten Limitationen der hier untersuchten mHealth Intervention (siehe Kap.

4.1.3. und 4.2.5). Eine Kombination psychologischer Interventionen wie der hier vorgestellten mit bekannten Elementen aus anderen mHealth GRMs, wie Ernährungsprotokollen, Kalorienzählern und Bewegungstracking, könnte die Effektivität in Bezug auf eine Gewichtsreduktion steigern (siehe Kap. 1.2). Darüber hinaus sollte eine gezielte Ernährungsumstellung hin zu Nahrungsmitteln mit einer geringeren Energiedichte angestrebt werden, sowie die körperliche Aktivität gesteigert werden. Menschen mit Übergewicht und Adipositas wird empfohlen sich 200-300 Minuten pro Woche moderat (spürbarer Anstieg der Herzfrequenz, bspw. beim schnellen Walking) bis intensiv (Atem- und Pulsfrequenz deutlich erhöht, bspw. Jogging) zu bewegen (Herpertz et al., 2022, S. 581-584). Dabei scheinen gruppenbasierte Programme, wie das Projekt *Football Fans in Training*, das sich über Bundesliga-Vereine organisiert, die Motivation zur Bewegung- und Ernährungsumstellung der Teilnehmenden zu steigern (Pietsch et al., 2020). Neben den über die App vermittelten psychologischen, ernährungs- und bewegungsspezifischen Informationen und Übungen, könnte ferner eine Kombination mit digitalen persönlichen Kontakten sinnvoll sein. Studien weisen darauf hin, dass persönliche Kontakte mit Behandelnden zu einer Steigerung der Adhärenz mit und Effektivität von psychologischen Interventionen beitragen (Becker et al., 2015). Dabei könnte der Kontakt bspw. in Form von Gruppengesprächen stattfinden, um die Kosten der Intervention zu reduzieren und die Motivation zu steigern (Shaw et al., 2005).

Zusammenfassend lässt sich folgern, dass die Bearbeitung psychosozialer Faktoren von Übergewicht und Adipositas, eine sinnvolle Ergänzung herkömmlicher GRMs darstellen könnte. Es bedarf der Entwicklung weiterer innovativer Ansätze zur Umsetzung multimodaler digitaler Adipositastherapie.

5.2 Food Addiction als Subgruppe von Menschen mit Übergewicht und Adipositas

Das Wissen um das Vorliegen von Essstörungen bei Menschen mit Übergewicht und Adipositas, spielt eine wichtige Rolle in der Gestaltung und dem Angebot therapeutischer Maßnahmen. FA ist bisher nicht als eigenständiges Störungsbild anerkannt. Ein weiteres Ziel dieser Arbeit war es,

Zusammenhänge von FA mit psychosozialen Faktoren, dysfunktionalem Essverhalten, sowie Übergewicht und Adipositas, getrennt von anderen Essstörungen zu betrachten und dadurch Evidenz in Bezug auf die Eigenständigkeit des Störungsbildes zu generieren.

Eine Subgruppe (15 %) von Menschen mit Übergewicht und Adipositas, bei denen im Vorfeld das Vorhandensein einer BES oder BN diagnostisch ausgeschlossen wurde, erfüllten die Kriterien einer FA Diagnose. Darüber hinaus zeigten sich Zusammenhänge zwischen FA und psychosozialen Faktoren, sowie dysfunktionalem Essverhalten und einem erhöhten BMI. Die Ergebnisse unterstützen die Sichtweise von FA als eigenständigem Störungsbild, stellen jedoch keinen hinreichenden Beweis dar (Gearhardt & Hebebrand, 2021). Durch die Betrachtung von FA als eigenständigem Störungsbild sollen Betroffene nicht pathologisiert werden. Vielmehr soll die Möglichkeit eröffnet werden, suchtspezifische Aspekte in die Behandlung von Ess- und Gewichtsstörungen einfließen zu lassen (Jiménez-Murcia et al., 2019; Schulte et al., 2016). In der hier vorgestellten Untersuchung zeigten sich Defizite der Teilnehmenden mit FA in der nahrungsbezogenen Inhibitionsfähigkeit und ein stark ausgeprägtes impulsives Essverhalten (Kap. 4.3.2). Auch Menschen mit Substanzkonsumstörungen zeigen meist impulsive Verhaltensweisen und Defizite in der Inhibitionsfähigkeit (Smith et al., 2014). Die hier generierten Ergebnisse basieren jedoch auf Selbstbeurteilungsfragebögen. Bisher wurde FA leider nicht systematisch mithilfe etablierter experimenteller Paradigmen aus der Suchtforschung untersucht (Müller & Steins-Loeber, 2022). Die Ergebnisse einer fMRT-Studie deuten jedoch darauf hin, dass Menschen mit FA sensibler auf Reize hochkalorischer und zuckerreicher Nahrungsmittel reagieren, als Menschen ohne FA (Schulte et al., 2019). Das hier beschriebene Craving der Teilnehmenden mit FA zeigte sich nicht bei Reizen von unverarbeiteten Nahrungsmitteln wie Obst, oder Nüssen. Analog zu Substanzkonsumstörungen, kann eine Abstinenz von bestimmten Nahrungsmitteln, die starkes Craving bei Menschen mit FA auslösen (bspw. Kuchen), zu einer langfristigen Reduktion des Verlangens führen (Meule, 2023). Reizkonfrontationstherapien und Übungen zur Steigerung der Inhibitionsfähigkeit, wie das Go-NoGo-Training oder die Approach-Avoidance-Task, könnten sinnvoll in die Therapie von Übergewicht und Adipositas bei Menschen

mit FA integriert werden (Müller & Steins-Loeber, 2022). Insgesamt zeigen Studien bisher heterogene Ergebnisse hinsichtlich des Einflusses von FA auf die Effektivität von GRMs (Burmeister et al., 2013; Clark & Saules, 2013; Fielding-Singh et al., 2019; Meule et al., 2015). Hier bedarf es der systematischen Untersuchung von FA bei spezifischen Therapietools, sowie der Entwicklung standardisierter klinischer Interviews zur valideren Diagnostik von FA (Schulte et al., 2020).

Zusammenfassend zeigt sich, dass eine relevante Subgruppe von Menschen mit Übergewicht und Adipositas die Diagnose einer FA erfüllt. Die Betroffenen zeigen analog zu Menschen mit Substanzkonsumstörungen Defizite in der Inhibitionsfähigkeit, sowie impulsive Verhaltensweisen. Es bedarf der systematischen Beforschung experimenteller Paradigmen, sowie der Entwicklung standardisiert klinischer Diagnosetools.

5.3 Geschlecht und Gender in der Psychotherapie

Das Konzept der Zweigeschlechtlichkeit gilt als gesellschaftlich und kulturell gemacht (Hyde et al., 2019). Auch neurobiologische und endokrinologische Studien deuten darauf hin, dass Geschlecht sich dimensional ausprägt (Hyde et al., 2019). Dennoch leben wir in einer Gesellschaft, in der wir von Geburt an von binären Geschlechts- und Rollenbildern geprägt werden. Es zeigte sich, dass bis Ende 2020 nur 0,00043% der volljährigen Bevölkerung in Deutschland ihr Geschlecht entsprechend des Urteils des Bundesverfassungsgerichtes von 2017 in „divers“ geändert haben (Die Zeit, 2021). Ebenfalls nur sehr selten ließen Eltern bis dahin das dritte Geschlecht bei Neugeborenen eintragen. Auch die Evidenz zur Ausgestaltung der Inhalte der I-GENDO Intervention wurde aus Studien generiert, die in der Regel geschlechtsdichotom untersuchten. Es zeigte sich jedoch, dass Interventionen, die diese Unterschiede berücksichtigen und entsprechend des angegebenen Geschlechtes fest zuordnen, keine bessere Effektivität aufwiesen, als Studien, die diese Unterschiede gar nicht berücksichtigten, also geschlechtsneutral angeboten wurden (Sharkey et al., 2020). In der Gestaltung der I-GENDO mHealth Intervention wurde ein innovativer gendersensibler Ansatz

verfolgt, dessen Effektivität im Vergleich zu geschlechtsdichotomen und geschlechtsneutralen Ansätzen jedoch zukünftig noch analysiert werden muss. Ebenso wichtig wäre es zukünftig in Studien die Geschlechtszugehörigkeit nicht nur kategorial (männlich, weiblich, divers), sondern auch dimensional, z.B. mithilfe von Fragebögen wie dem Personal Attributes Questionnaire (PAQ, Tibubos et al., 2022) zu erfassen und diese in die Analysen mit einfließen zu lassen.

Eine stärkere Berücksichtigung von Geschlecht und Gender wird auch in der psychotherapeutischen Praxis gefordert (Hyde et al., 2019). In ihrem Buch „Psychotherapie und Gender. Konzepte. Forschung. Praxis“ beschreibt Brigitte Schigl die Notwendigkeit Gender als dyadisches Konzept zu verstehen, welches sich erst in der sozialen Interaktion definiere (Schigl, 2018, S. 7-27). So habe jedes Individuum ein eigenes Geschlechts- und Rollenverständnis, welches in die Interaktion einfließe und das eigene Verhalten, sowie die Wahrnehmung des Gegenübers beeinflusse. Als praktizierende Forschende oder TherapeutInnen arbeitet man demnach mit Gender-Phänotypen, deren zugrundeliegendes Rollen- und Geschlechtsverständnis durch die Gesellschaft und das soziale Umfeld meist binär geprägt wurde. Fachlicherseits sollten kategoriale Denkmuster jedoch aufgebrochen, sowie das eigene Genderverständnis in der Interaktion berücksichtigt werden.

5.4 Einbettung der Ergebnisse in das Biopsychosoziale Modell von Übergewicht und Adipositas

Die Herleitung der in dieser Dissertation betrachteten Fragestellungen basierte auf dem Biopsychosozialen Modell der Entstehung und Aufrechterhaltung von Übergewicht und Adipositas (Lehrke & Laessle, 2009, siehe Kap. 1.3). Dabei wurden psychosoziale Faktoren beschrieben und analysiert. Im Folgenden soll noch medizinische und soziokulturelle Einflussvariablen in der Entstehung und Aufrechterhaltung von Übergewicht und Adipositas, sowie daraus abgeleitete Behandlungsansätze eingegangen werden.

5.4.1 Medizinische Aspekte

Genetische Prädispositionen für Übergewicht und Adipositas zeigen sich sowohl in Hinblick auf die Energieaufnahme, als auch auf die Energieabgabe. So zeigte eine dänische Adoptionsstudie, dass es keinen statistischen Zusammenhang zwischen dem Körpergewicht der Adoptivkinder und ihrer Adoptiveltern gab, jedoch mit den leiblichen Eltern (Stunkard et al., 1986). Insgesamt können genetische Varianten bisher ca. 6-11% der Variabilität des BMIs aufklären (Speliotes et al., 2010), wobei vermehrt Mutationen des Leptin-Rezeptors festgestellt wurden (Hinney et al., 2010). Vor allem über die Hormone Leptin und Ghrelin werden Sättigung und Hunger im Körper reguliert. Bei Menschen mit Übergewicht und Adipositas kann ein Ungleichgewicht der Hormonspiegel zu vermehrtem Hunger bzw. verringertem Sättigungsgefühl beitragen. Der Ruheenergieverbrauch (Grundumsatz) variiert zwischen den Geschlechtern und nimmt mit zunehmendem Alter und Körperfettanteil ab. Auch hier zeigen sich genetische Prädispositionen. Zudem können körperliche Erkrankungen, wie Hypothyreose, Schlafmangel und Medikamente, wie Kortikostereoide, zu Übergewicht und Adipositas beitragen (Herpertz et al., 2022, S. 435-442).

Eine medikamentöse Therapie wird in Deutschland aktuell nur adjuvant zur Ernährungs-, Bewegungs- und Psychotherapie der Adipositas empfohlen (S3-Leitlinie). Wie bereits oben beschrieben wird bei Adipositas Grad III und erfolgloser konservativer Behandlung, ein Adipositas-chirurgischer Eingriff empfohlen (Kap.1.2). In den vergangenen Jahren wird vermehrt der Einfluss von gastrointestinalen Mikrobiotika auf das Gewicht beforscht, sowie Ideen zur Adipositastherapie mit Probiotika entwickelt (Herpertz et al., 2022, S. 476-478).

5.4.2 Soziokulturelle Aspekte

Historisch betrachtet kann seit Ende des 19. Jahrhunderts eine stetige Zunahme der Körpergröße und des Körpergewichts der europäischen Bevölkerungen festgestellt werden, welche nur in Zeiten der beiden Weltkriege kurzfristig rückläufig war (Schmidt-Semisch & Schorb, 2008, S. 36-39). Zurückzuführen ist dies u.a. darauf, dass sich mit Beginn der industriellen Revolution im 18. und 19.

Jahrhundert die Arbeitsbedingungen der Menschen in den Industrienationen verändert haben. Körperlich anstrengende Arbeitsprozesse konnten immer mehr maschinell unterstützt werden, wodurch der tägliche Energieverbrauch reduziert wurde. Durch den Ausbau der industriellen Landwirtschaft und Verbesserung der Transportwege, ist die Energiezufuhr gleichzeitig nicht zurückgegangen. Heute leben wir in einer adipogenen Gesellschaft, in welcher fett- und zuckerreiche Nahrungsmittel u.a. in Form von Fast Food und Lieferdiensten unkompliziert und ohne nennenswerten Energieverbrauch verfügbar sind, während sowohl im Arbeits-, als auch im Freizeitbereich eine Verschiebung von körperlich aktiven zu sitzenden Tätigkeiten festgestellt werden kann (Lake & Townshend, 2006).

Neben der Erforschung effektiver Therapien von Übergewicht und Adipositas, bedarf es demnach auch einer Veränderung der adipogenen Umweltbedingungen in unserer Gesellschaft seitens der Politik (Gerlach & Blüher, 2018; Swinburn et al., 1999). Dazu zählen beispielsweise verhältnispräventive Ansätze wie bspw. das Einführen des Nutri-Scores, mithilfe dessen Produkte hinsichtlich ihres Nährwertes anhand einer Skala von A (dunkelgrün) bis E (rot) miteinander vergleichbar gemacht werden (Bundesministerium für Ernährung und Landwirtschaft, 2020). Darüber hinaus bedarf es einer besseren Aufklärung über gesunde und ungesunde Ernährungsweisen, bspw. in Schulen. Die Ergebnisse dieser Dissertation verdeutlichen zudem den suchtartigen Charakter, den Essen zumindest für einige Menschen haben kann. Hier könnten suchtpräventive Ansätze, wie bspw. Werbebeschränkungen, die es bei Alkohol und Tabak bereits gibt, für bestimmte Nahrungsmittel sinnvoll sein.

Darüber hinaus bedarf es aber auch eines gesellschaftlichen Umdenkens in der Betrachtung und im Umgang mit Übergewicht und Adipositas. Carmen Gransee kritisiert gesellschaftlich verankerte normative Vorstellungen von Idealkörpern, sowie die Interpretation von „Schlankheit als Freiheit“ und Disziplinlosigkeit bei Übergewicht (in: Schmidt-Semisch & Schorb, 2008, S. 164-165). Das Verfolgen idealtypischer „body images“ kann zu psychischer Belastung und der Entstehung von Essstörungen beitragen (in: Schmidt-Semisch & Schorb, 2008, S. 165-168). Zudem erfahren viele

Menschen mit Übergewicht und Adipositas im Alltag und im Beruf gewichtsbezogene Diskriminierung, wodurch die psychische Belastung der Betroffenen steigt und sie meist weiter an Gewicht zunehmen (siehe Kap. 1.4). Hier bedarf es neben der schon beschriebenen gesundheitspolitischen Aufklärungsarbeit, auch einer Veränderung der medialen Darstellung von Körperidealen.

6. Fazit

Digitale Interventionen werden in der Adipositastherapie aufgrund ihrer Kosteneffizienz und der guten Implementierbarkeit in den Alltag Betroffener eine immer größere Rolle spielen. Dabei sind mHealth Lebensstilinterventionen effektiv, jedoch zeigen sich bessere Effekte, wenn diese mit analogen psychotherapeutischen Angeboten ergänzt werden. Durch die digitale Bearbeitung psychosozialer Faktoren von Übergewicht und Adipositas kann das dysfunktionale Essverhalten teils nachhaltig verbessert werden. Eine Ergänzung um etablierte Elemente wie Ernährungsprotokolle, sowie eine adjuvante Bewegungssteigerung, und Kombination mit digitalen persönlichen Kontakten, könnte als multimodale digitale Therapie der Adipositas einen innovativen Ansatz zur Reduktion von Übergewicht und Adipositas darstellen. Bei der Ausgestaltung zukünftiger Interventionen ist auch die Einbindung suchtspezifischer Behandlungselemente relevant, da eine Subgruppe von Menschen mit Übergewicht und Adipositas die Kriterien einer Food Addiction erfüllt.

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Anhang

Anhang A: A Tailored Gender-Sensitive mHealth Weight Loss Intervention (I-GENDO): Development and Process Evaluation

Pape, M., Färber, T., Seiferth, C., Roth, T., Schroeder, S., Wolstein, J., Herpertz, S.& Steins-Loeber, S. (2022). A Tailored Gender-Sensitive mHealth Weight Loss Intervention (I-GENDO): Development and Process Evaluation. *JMIR Formative Research*, *6*(10), e38480. doi: 10.2196/38480

Original Paper

A Tailored Gender-Sensitive mHealth Weight Loss Intervention (I-GENDO): Development and Process Evaluation

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Abstract

Background: Given the increase in the prevalence of overweight and obesity worldwide, the number of digital weight loss interventions has also risen. However, these interventions often lack theoretical background and data on long-term effectiveness. The consideration of individual and gender differences in weight-related psychological parameters might enhance the efficacy and sustainability of mobile-based weight loss interventions.

Objective: This paper presented an introduction to and the process evaluation of a 12-week gender-sensitive mobile health (mHealth) weight loss intervention (I-GENDO) combining computer-based and self-tailoring features.

Methods: Between August 2020 and August 2021, individuals with overweight (BMI 25.0-29.9 kg/m²), those with obesity class I (BMI 30.0-34.9 kg/m²), and those with obesity class II (BMI 35.0-39.9 kg/m²) were recruited to the I-GENDO project, a multicenter study in Germany. The mHealth intervention aimed at targeting individual psychological factors associated with the development and persistence of overweight and obesity (eg, emotional eating) using computer-based tailoring. Moreover, the intervention took a gender-sensitive approach by implementing self-tailoring of gender-targeted module versions. The computer-based assignment of the main modules, self-selection of gender-targeted module versions, and use patterns were evaluated while considering gender. Moreover, gender differences in the usability assessment were analyzed.

Results: Data from the intervention arm of the study were processed. A total of 116 individuals with overweight and obesity (77/116, 66.4% women; age mean 47.28, SD 11.66 years; BMI mean 33.58, SD 3.79 kg/m^2) were included in the analyses. Overall, the compliance (90/109, 82.6%) and satisfaction with the app (mean 86% approval) were high and comparable with those of other mobile weight loss interventions. The usability of the intervention was rated with 71% (5.0/7.0 points) satisfaction. More women obtained the main module that focused on emotion regulation skills. Most men and women selected women-targeted versions of the main modules. Women used the app more frequently and longer than men. However, women and men did not differ in the progress of use patterns throughout the intervention.

Conclusions: We developed a tailored gender-sensitive mHealth weight loss intervention. The usability of and engagement with the intervention were satisfactory, and the overall satisfaction with the intervention was also high. Gender differences must be considered in the evaluation of the effectiveness and sustainability of the intervention.

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KEYWORDS

mobile health; mHealth; eHealth; tailoring; gender; weight loss intervention; mobile phone

Introduction

Within the last few decades, a vast number of digital health apps have been developed worldwide [1,2]. eHealth interventions (ie, mobile health [mHealth] interventions) are cost-effective and feasible in everyday life and represent a useful addition to analog health care services, not only in times of a worldwide pandemic [3]. In 2021, 87% of German adults and adolescents aged >14 years owned a smartphone, and 27% reported using mHealth interventions regularly [4]. The use of mHealth interventions requires an active and self-determined engagement of the user and therefore facilitates behavioral changes [5]. For example, mHealth lifestyle interventions show good efficacy in promoting healthy behaviors such as dietary intake and physical activity [6-10]. Therefore, they are promising tools that could promote behavioral change in participants wishing to reduce weight [11]. However, most available interventions to date demonstrate only short-term effects of behavioral change, whereas long-term effectiveness, especially regarding weight loss, has either not been investigated or not been demonstrated [12-14]. An explanation for the lack of effects is that most weight loss apps have not been developed from a scientific background and thus lack sufficient consideration of psychological evidence-based strategies [15], which are an important aspect of effective weight loss programs (WLPs) according to international guidelines [16,17]. Moreover, most weight loss apps have been developed on a *one-size-fits-all* approach, despite indications from prior studies that targeted (tailored) interventions are more effective [18-20].

The term "tailoring" refers to the customization of a feature of an intervention based on the individual characteristics of the participants [21]. The participants might customize an intervention based on their own preferences (self-tailoring), or they might receive individualized interventions in which the program tailors the content, usually based on algorithms (computer-based tailoring). In the latter case, tailoring can be based on data from 1 assessment (static tailoring) or adapted to different assessments within an intervention process (dynamic tailoring). Studies have indicated that participants feel more strongly addressed by individualized interventions, are more satisfied with them, and are subsequently more engaged in their use, which enhances the efficacy of the programs [6,11,19,22-25]. Various psychological aspects are involved in the development and maintenance of overweight and obesity, including the experience of weight-related stigmatization [26], maladaptive coping strategies [27], or dysfunctional eating behaviors [28]. Therefore, developing computer-based tailoring features that consider such psychological aspects might be a key element in the optimization of digital WLPs.

Gender differences in the development and treatment of obesity and overweight have also been investigated [29,30]. In Germany, more men (43.3%) develop overweight (BMI 25-29.9 kg/m²) compared with women (28.8%), but there are no gender differences in the prevalence of obesity (BMI >30.0 kg/m²), with increasing prevalence rates in the past decades among both genders [31,32]. Men with overweight and obesity are less likely to accurately perceive their weight and are less dissatisfied with their overweight status [29]. Moreover, gender differences in physical activity, eating behavior, and weight-related psychological parameters have been reported. For example, women engage more often in problematic eating behaviors, such as emotional eating (EE) and craving of special foods than do men [33]. Women consistently report higher levels of perceived stress and engage more in emotion-focused coping, such as rumination, whereas men often use problem-focused or avoidant coping strategies [34,35]. On average, men are more physically active [36]. Some biological sex differences have been published; for instance, in males, fat depositions are often in the visceral depot, which increases their risk for cardiovascular disorders [37-39]. More women participate in WLPs, yet the participating men lose more absolute weight [40,41]. Results on the adherence to WLPs are heterogeneous, depending on the intervention type, among other factors [42-44]. On the basis of reviewed studies, investigating the effect of gender on overweight and obesity outcomes to improve the effectiveness of WLPs is an important research agenda. A recently published meta-analysis comparing the effects of gender-targeted and gender-neutral WLPs however revealed no differences in weight-related outcomes, although gender-targeted interventions were more effective in promoting activity and improving nutrition [45]. However, the included *gender-targeted* WLPs were offered either to male or to female participants based on sex. We support the idea that psychological interventions should be gender sensitive instead of gender dichotomous and assume an increase in the effectiveness of the intervention if it is gender sensitive [46]. Therefore, to avoid prejudiced gender-based distinctions between individuals with overweight and obesity, we recommend implementing gender-sensitive self-tailoring features.

Against this background, we aimed at developing a smartphone-based psychological and gender sensitive weight-loss intervention with computer-based and self-tailoring features. In the first part of this paper, we have described the development process of the app with particular focus on the tailoring features of the intervention. The subsequent process evaluation focuses on the evaluation of the app with regard to the psychological and gender-sensitive tailoring features, use patterns, and satisfaction with the app derived from a sample of 116 participants taking part in the I-GENDO project [47].

Methods

The I-GENDO Project

The project "Gender-sensitive enhancement of common weight-loss strategies for overweight and obesity: A personalized smartphone app" was proposed by the University of Bamberg, Departments of Clinical Psychology and Psychotherapy and Pathopsychology, in cooperation with LWL-University Hospital of Ruhr-University Bochum, Department of Psychosomatic Medicine and Psychotherapy, and funded by the Federal Ministry of Education and Research of Germany (01GL1719A/B). The project was preregistered (ClinicalTrials.gov identifier: NCT04080193).

Ethical Considerations

This study was conducted in accordance with the Declaration of Helsinki. The Institutional Review Board of Ruhr-University

Bochum approved the study (number 18-6415). All participants were informed about the study and provided written informed consent.

Development of the mHealth Intervention I-GENDO

From September 2017 to November 2019, a modular app system was developed at the University of Bamberg in cooperation with an external software provider (groupXS Solutions GmbH).

Figure 1. The I-GENDO app interface.

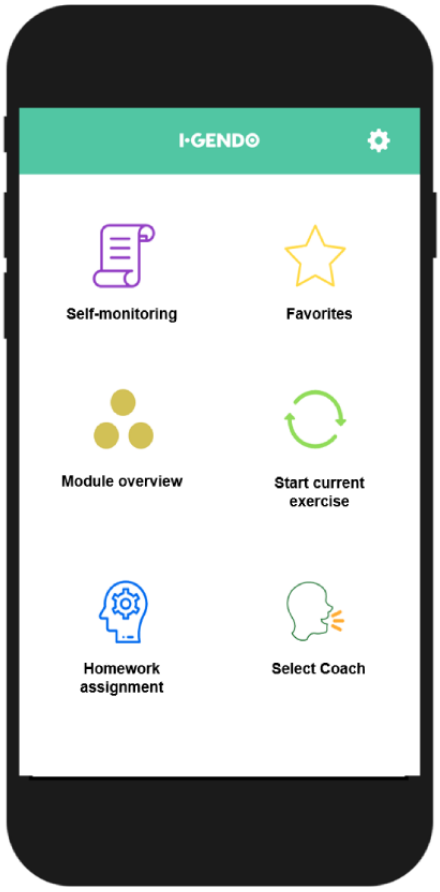


Figure 1 provides an overview of the I-GENDO app interface. The app provided the following elements: module-based psychological intervention; selection of an accompanying coach; and self-monitoring of hunger, appetite, and mood.

The content of the modules was based on the existing evidence-based manuals, qualitative data from focus groups of individuals with overweight and obesity, and interviews with experts in the field of psychological treatment of obesity. To implement a gender-sensitive approach, extensive literature reviews were conducted on the disparities between genders in the psychological and behavioral aspects of obesity treatment. Furthermore, a steering committee consisting of experts in the field of prevention and treatment of overweight and obesity, digital transformation, and qualitative data analyses was formed. All principal decisions regarding app development were made in consensus with the members of the steering committee.

On the basis of this information, 7 modules that served as the heart of the 12-week I-GENDO intervention were constructed. Of the 7 modules, 2 modules addressed the introduction to (goal setting) and conclusion (relapse prevention strategies) of the intervention. The remaining 5 modules (main modules) focused on different psychological parameters associated with the development and maintenance of overweight and obesity: stress management skills (*stress module*), emotion regulation skills (*emotion module*), dealing with the consequences of overweight (*consequences module*), self-regulation skills (*control module*), and self-efficacy (*self-efficacy module*). Each module contained 9 sessions, which included psychoeducational elements delivered through texts and videos, several therapeutic tools from different therapeutic approaches (ie, cognitive behavioral therapy, dialectical behavioral therapy, and mindfulness), and various behavior change techniques [48]. These sessions could be repeated as many times as desired, and users could set a short link to their favorite exercises via the toolbox.

Each module was presented in either a women-targeted version (*version A*) or a men-targeted version (*version B*), which differed in terms of knowledge transfer, communication style, and prioritization of topics. For example, in the *stress module*, this was achieved using appealing case examples in the women-targeted version and fact presenting in the men-targeted version to transfer general knowledge about stress. Another example is that the men-targeted version in the *emotion module* highlighted and trained the recognition and labeling of emotions, whereas in the women-targeted version, the association between

dysfunctional beliefs and eating behavior was prioritized. Multimedia Appendix 1 [48-77] provides an overview of the operationalization of the gender-sensitive modules and the origin of evidence. The versions were briefly introduced, with both introductions presented on 1 screen page. Participants could then freely choose between *version A* or *B* regardless of biological sex (gender-sensitive instead of gender dichotomous tailoring). Participants were blind to the manipulation of the gender-targeted versions.

Process Evaluation of the mHealth Intervention I-GENDO

From December 2019 to December 2021, the effectiveness of the 12-week I-GENDO intervention was evaluated in a randomized controlled trial conducted at the University of Bamberg and LWL-University Hospital Bochum, Department of Psychosomatic Medicine and Psychotherapy (ClinicalTrials.gov Identifier: NCT04080193). The main results of the randomized controlled trial will be published elsewhere. In this manuscript, the relevant process evaluation data from the intervention arm were analyzed.

Study Sample

Individuals were informed about the I-GENDO project via newspaper articles, radio features, and oral presentations at rehabilitation centers. Participants interested in the study were screened for eligibility (Textbox 1) and, if eligible, were invited to participate. According to the guidelines of the German Association for the Study of Obesity and the German Society for General and Visceral Surgery, individuals with obesity class III (BMI >39.9 kg/m^2) experience a complex multifactorial framework of severe social, mental, and physical problems and are recommended to undergo bariatric surgery. Therefore, we excluded individuals with obesity class III from participation but provided further support. Because the effect of bariatric surgery on weight loss is mainly driven by physical limitations and varies significantly between the types of operative procedure [78], we decided to exclude individuals who underwent or planned to undergo bariatric surgery. The total study sample consisted of 213 individuals with overweight and obesity, of which 116 (n=77, 66.4% women) were randomly assigned to the intervention group for this study and subsequently included in this analysis.

Textbox 1. Eligibility criteria of the I-GENDO project.

Inclusion criteria

- Legal age (≥18 years)
- Obesity class I or II with subjectively experienced weight-related impairment and a current intention to lose weight
- Overweight (ie, BMI between 25 and 29.9 kg/m²) with weight-related health problems, visceral adipose tissue, or high psychosocial weight-related distress and a current intention to lose weight

Exclusion criteria

- Obesity class III (ie, BMI >39.9 kg/m²)
- Current (or within the last 12 months) involvement in a structured weight loss intervention
- Insulin-dependent type 1 diabetes
- Previous or intended bariatric surgery
- Current psychotherapeutic treatment of weight-related health problems
- Weight-enhancing drugs
- Drugs that promote weight loss (eg, antiobesity drugs)
- Weight-enhancing health problems that are not yet treated
- Cancerous disease within the last 5 years
- Current substance-use disorders, major depression, psychosis, suicidal tendency, or pregnancy
- Severe cognitive impairments
- Insufficient knowledge of the German language
- Binge-eating disorder or bulimia nervosa

Intervention Phase

Participants in the intervention group received a 12-week tailored app intervention. In the first week of intervention, the introduction module was unlocked for each participant, followed by 9 weeks of tailored intervention comprising 3 of the 5 main modules. Each session of the 3 main modules was unlocked successively between weeks 2 and 9. The basic, minimal content of the remaining 2 modules was provided in the form of mini modules, which were unlocked in week 11. Finally, the conclusion module was provided to each participant in week 12.

Tailoring

Figure 2 displays computer-based and self-tailoring features of the intervention. The introduction and conclusion module were mandatory elements framing the intervention that conveyed general content, whereas the main modules targeted individual

differences in weight-related psychological parameters. The main module assignment was computer-based and depended on the results of the Revised Illness Perception Questionnaire (IPQ-R), a standardized questionnaire adapted to overweight and obesity that measures illness beliefs (eg, "my overweight strongly affects the way others see me") and causal attribution of overweight (eg, "my emotional state, e.g. feeling down, lonely, anxious, empty") [79]. Participants completed the IPQ-R at the baseline assessment. Each of the 32 items were rated on a 5-point Likert scale ranging from 1 ("strongly disagree") to 5 ("strongly agree"). In this study, the internal consistency of the scale was good (Cronbach α=.714). Scales were regenerated with higher means representing severe problems on the related psychological parameters associated with overweight and obesity (eg, EE). Of the 5 dimensions, 3 on which the participants reported the highest impairments were tailored to the participants (computer-based tailoring). In addition to the computer-based tailoring feature, individual adaption of content and functions was enabled (self-tailoring). Each module was presented in either a men-specific (*version B*) or a women-specific version (*version A*; "App features" section and Multimedia Appendix 1). The app additionally contained customization features to enhance the adherence to the intervention [80]. In particular, the participants could choose between different coaches at the beginning of the 12-week intervention. A total of 4 different coaches were introduced: 2 men and 2 women coaches depicted as being either more friendly (eg, informal and motivating tips) or more professional (eg, formal and directive tips).

Figure 2. Tailoring features of the I-GENDO intervention. Of the 5 main modules (in the box), 3 were assigned to the participants based on the results of the revised illness perception questionnaire (computer-based tailoring). Each of the modules was presented in either a women- or men-targeted version (self-tailoring).

Measurements

Engagement With the App

Use patterns were retrieved from individual app data and subsequently analyzed. Actions were defined as time slots of active engagement with the app, for example, log-in to the app and processing a session (use frequency). Inactivity for 20 minutes defined the completion of one action. The overall app use time was calculated in minutes (use time). The participants who used the app at least 12 times (actions) and for 120 minutes within the 12-week intervention were defined as being compliant with the I-GENDO app.

Satisfaction With the App

At the end of the conclusion module, the users could give feedback about their satisfaction with the app and the relevance and daily usefulness of the app on scales ranging from 0 ("not at all") to 100 ("very much"). In the last session of each module, participants could evaluate how satisfied they were with the corresponding module.

Usability Rating of the App

After the 12-week intervention, the mHealth App Usability Questionnaire for stand-alone mHealth apps used by patients was administered [81]. The original English questionnaire was translated into German by a member of the research group and retranslated by a native speaker. Deviations were discussed and subsequently adjusted. The self-report questionnaire consisted of 18 items, which were scored on a scale from 1 ("strongly disagree") to 7 ("strongly agree"), with higher means reflecting higher usability. Prior research indicated good psychometric properties of the English version of the mHealth App Usability Questionnaire [81]. In this study, the internal consistency of the total scale was excellent (Cronbach α=.935).

Data Analysis

All analyses were conducted using SPSS for Windows (version 26.0; IBM Corp) and Excel (version 16.0; Microsoft Corp). App data were retrieved from Apache CouchDBTM. Descriptive analyses were conducted using percentages and frequencies for categorical variables and means and SDs for continuous variables. *Chi-square* distributions that compared categorical variables between genders were implemented, and Bonferroni-adjusted independent 2-tailed *t* tests were conducted to compare metrically scaled variables. Mann-Whitney *U* tests were conducted to compare results between genders on nonnormally-distributed variables. Friedman tests and Dunn-Bonferroni post hoc tests were implemented to compare app engagement between genders over the 12 weeks of intervention.

Results

Participants

We found no significant gender differences in age, BMI, marital status, and education level at baseline (Table 1).

Table 1. Sociodemographic factors (N=116).

Characteristic	Overall	Women (n=77)	Men (n=39)	Women vs men		
			2-tailed t test (*df*)	Chi-square (*df*)	*P* value[a]
Age (years), mean (SD)	47.28 (11.66)	46.40 (12.22)	49.00 (10.38)	1.14 (114)	N/A[b]	.26
BMI (kg/m^2), mean (SD)	33.58 (3.79)	33.75 (3.69)	33.23 (4.02)	0.70 (114)	N/A	.49
Marital status (yes), n (%)[c]	91 (78.4)	57 (74)	34 (87)	N/A	1.9 (1)	.17
Education (university), n (%)[d]	36 (31)	25 (32)	11 (28)	N/A	0.1 (1)	.80

[a]Bonferroni-adjusted *P* values.

[b]N/A: not applicable.

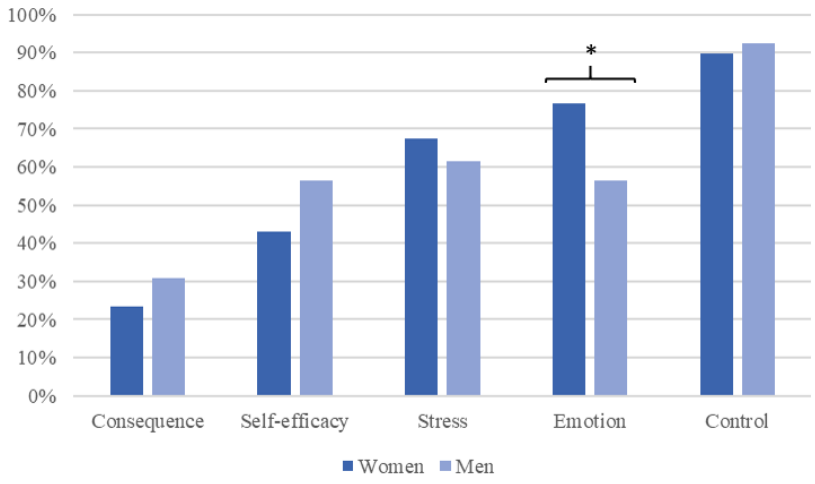
[c]Number of participants in a relationship.

[d]Number of participants with a university degree.

Tailoring

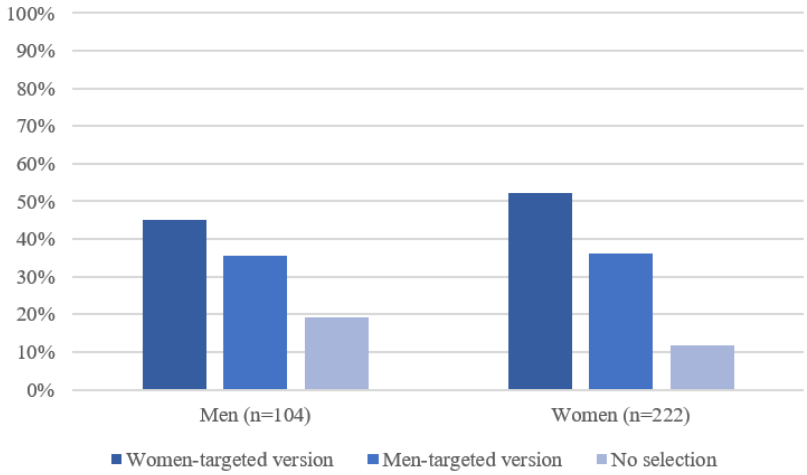
Three main modules were tailored to each of the 116 participants by computer-based tailoring according to their IPQ-R results (see the section *Tailoring*). Most participants (105/116, 90.5%) received the *control module*, followed by the *emotion module* (81/116, 69.8%), *stress module* (76/116, 65.5%), and *self-efficacy module* (55/116, 47.4%). One-quarter of the participants (30/116, 25.9%) received the *consequence module*. Figure 3 illustrates the module assignments for the participating men and women separately. Significantly more women obtained the *emotion module* than men (χ^2_1=4.1; *P*=.04; ϕ=0.21). The genders did not differ in the assignment of the *consequence* (χ^2_1=0.4; *P*=.53), *self-efficacy* (χ^2_1=1.6; *P*=.23), *stress* (χ^2_1=0.2; *P*=.66), or *control module* (χ^2_1=0.02; *P*=.89).

Figure 3. Assigned full-version modules (computer-based tailoring) in percentage (**P*<.005).



As described earlier, at the beginning of each module, the participants were instructed to choose between either a women-targeted or a men-targeted version (self-tailoring). In 50% (163/326) of the choices, the women-targeted versions were selected (women: 116/222, 52.3%; men: 47/104, 45.2%). In 35.9% (117/326) of the choices, the men-targeted versions were selected (women: 80/222, 36%; men: 37/104, 35.6%). In the remaining 14.1% (46/326) of the choices, no selection was made (Figure 4). When the participants did choose a version, they chose version A 58.2% (163/280) of the time (women: 116/196, 59.2%; men: 47/84, 56%).

Figure 4. Module version assignments (self-tailoring) in percentage (total choices: N=326).



Another customization feature of the intervention was the selection of an accompanying coach when starting the app for the first time. Most women (35/74, 47%) chose a friendly woman coach, 19% (14/74) chose a professional man coach, 18% (13/74) chose a friendly man coach, and 16% (12/74) chose a professional woman coach. Coach assessment in men was more balanced, with 34% (12/35) choosing a friendly woman coach, 23% (8/35) choosing a friendly man or professional woman coach, and 20% (7/35) choosing a professional man coach. No significant gender differences were found in coach assessment (χ^2_3=1.9; *P*=.60).

Engagement With the App

Of the 116 participants in the intervention group, 109 actively participated in the app intervention phase. During the 12-week intervention period, the use frequency and use time were recorded.

We found significant gender difference in use frequency (*U*=908.00; *z* score=−2.51; *P*=.01; *r*=−0.24) and use time (*U*=736.00; *z* score=−3.63; *P*<.001; *r*=−0.35). The participating women used the app 97 (SD 88.03) times and for 625 (SD 427.94) minutes on average throughout the intervention, whereas the participating men used the app 56 (SD 45.62) times and for 347 (SD 285.68) minutes on average. In total, 82.6% (90/109) of the users were compliant with the app (women: 63/74, 85%; men: 27/35, 77%).

During the 12-week intervention phase, the use time (χ^2_{11}=126.03; *P*<.001) and use frequency (χ^2_{11}=139.51; *P*<.001) of the participating men (n=35) decreased (Figures 5 and 6). The use time, (χ^2_{11}=231.34; *P*<.001) and use frequency (χ^2_{11}=309.16; *P*<.001) of the participating women (n=74) also decreased. Dunn-Bonferroni post hoc tests revealed a significant decrease in use time within the first 3 weeks of intervention (*z* score=3.99; *P*<.001; *r*=0.46). From week 3 to week 12, use time and frequency leveled off at approximately 6.56 (SD 7.21) actions per week and 41.99 (SD 34.03) minutes per week for the participating women and 3.53 actions per week (SD 3.36) and 21.75 minutes per week (SD 21.88) for the participating men. We found no gender differences in use time progress (*U*=1075.00; *z* score=−1.43; *P*=.15) and use frequency progress (*U*=1106.00, *z* score=−1.23; *P*=.22) during the 12-week intervention period.

Figure 5. Use time per week in minutes (means and SEs of means).

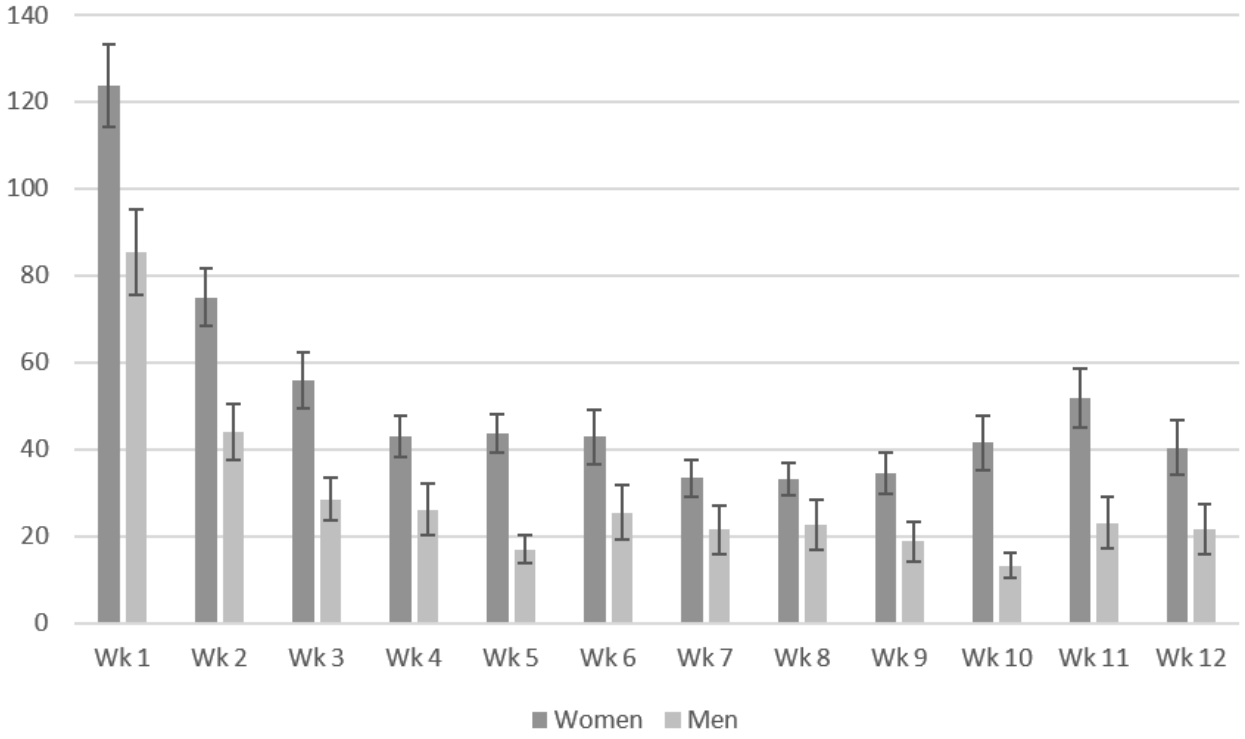
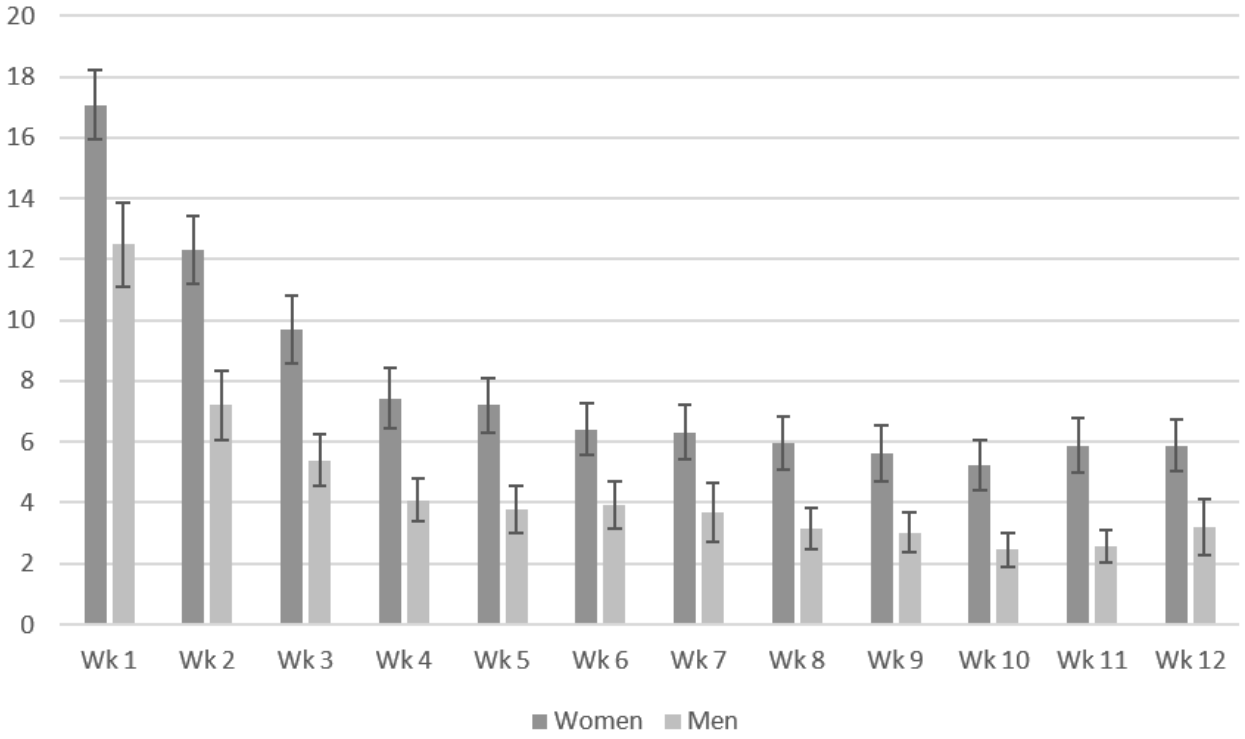


Figure 6. Use frequency per week in actions (means and SEs of means).



Evaluation of the App

After completion, 41 participants evaluated the I-GENDO app. On average, the overall satisfaction with the app was high (mean 85.54, SD 19.36). In addition, the relevance of the content (mean 83.34, SD 20.03) and daily life usefulness (mean 78.95, SD 22.24) were evaluated as satisfactory. Of the main modules, the *stress module* (n=36) was rated best (mean 82.92, SD 14.05), followed by the *emotion module* (n=50; mean 81.66, SD 16.45), the *control module* (n=60; mean 80.47, SD 18.08), the *self-efficacy module* (n=29; mean 78.48, SD 17.66), and finally the *consequence module* (n=16; mean 67.75, SD 21.68).

In addition to the evaluation, the usability of the app was assessed using a standardized questionnaire (see the section *Usability Rating of the App*). The usability of the app was rated, on average, with 71% satisfaction (mean 5.00, SD 1.08 points; maximum: 7.00 points). No gender differences could be found between the usability ratings of men (mean 4.72, SD 1.07) and women (mean 5.13, SD 1.07; t_{99}=−1.76; *P*=.08).

Discussion

Overview

We aimed to introduce the I-GENDO app, a tailored gender-sensitive mHealth weight loss intervention, and present results from its process evaluation data. Therefore, data from the intervention arm of the I-GENDO project were analyzed. The sample included 116 (n=77, 66.4% women) individuals with overweight and obesity.

Principal Findings

We developed a module-based 12-week intervention combining computer-based and self-tailoring features. Most participants (105/116, 90.5%) received the *control module*, which focused on self-regulation skills of food craving. The *stress module* was assigned to 65.5% (76/116) of the participants, and the *self-efficacy module* to 47.4% (55/116). The *consequence module* was obtained by 25.9% (30/116) of the participants. Significantly more women (59/77, 77%) than men (22/39, 56%) received the *emotion module*. Another tool of the intervention was the implementation of gender-sensitive self-tailoring features. We developed women- and men-targeted versions of the main modules. At the beginning of each module, participants could choose between the 2 versions. Among the participants who chose a version, *version A* was chosen 58.2% (163/280) of the time (women: 116/196, 59.2%; men: 47/84, 56%), which means that among both genders, the women-targeted module versions were predominantly selected.

In total, 82.6% (90/109) of the participants (women: 63/74, 85%; men: 27/35, 77%) were compliant with the I-GENDO app during the intervention phase. Use time and frequency significantly decreased during the 12-week intervention phase for both genders. After the first 3 weeks of intervention, use time leveled off and remained stable at approximately 42 minutes per week for the participating women and 22 minutes per week for the participating men. Similarly, use frequencies were approximately stable as of week 3 for both genders. Compared with the women, the men used the app infrequently and spent less time with the app. Nevertheless, the average use times and frequencies in both genders were satisfactory even in the last weeks.

The overall satisfaction with the app was high, with almost 86% (86/100) approval. In addition, the daily life usefulness and relevance of the content were ranked satisfactory by 79% (79/100) and 83% (83/100) of participants, respectively. The highest-rated main module was the *stress module* (83/100, 83%), but even the satisfaction with the *consequence module* was acceptable (68/100, 68%). In general, the usability ratings indicated that the I-GENDO intervention was good, averaging 5.0 out of 7.0 points (71%).

Comparison With Prior Work

The heterogeneous computer-based administration of the main modules supports the tailoring feature. The *control module* was assigned to most participants. This is in line with the observation that decreased food-related inhibitory control is regularly associated with overweight and obesity [49,82,83]. Gender differences were found in the computer-based assignments of the *emotion module*, which significantly more women obtained. The module focused on dysfunctional emotion regulation and associations between negative emotions and (eating) behavior. EE refers to problems in the distinction between physiological appetite and eating as a strategy to cope with negative feelings [84]. EE is correlated with higher weight, severe depression symptoms, and the consumption of sweet energy-dense foods [85]. More women report negative emotions as causes for their overweight and engage more often in EE compared with men [50,85,86]. EE is associated with less intuitive eating by women, which could be a barrier to the implementation of healthy eating behaviors [87]. Studies indicate that more women undergo weight loss treatment, whereas participating men lose more absolute weight [29]. Focusing more on EE in treatment might contribute to a close in this gap. In addition, previous studies indicated that a relevant subgroup of individuals with overweight and obesity exhibit addiction-like eating behavior (ie, food addiction [FA]), characterized by an impaired food-related inhibitory control, EE, and food craving [88,89]. The prevalence of FA is higher in women than in men and is among other factors associated with higher BMI, dysfunctional eating behavior, and psychological distress [90,91]. Some studies reported lower adherence to and decreased effectiveness of WLPs in individuals experiencing FA, whereas others found no influence of FA on the success of WLPs [92-95]. As the *control* and *emotion* modules implement the treatment of dysfunctional EE behavior and exercises to improve food-related inhibitory control, participants experiencing FA might especially benefit from the intervention. Thus, the association between FA and the effectiveness of our intervention should be further investigated.

One-quarter of the participants received the *consequences module*, which focused on weight-related discrimination and the improvement of self-esteem and body image, as well as the social competences to deal with discrimination. The extent of this use might explain the prevalence of weight discrimination being higher in our sample than in the results of a representative German study reporting prevalence rates ranging from 5.6% to 18.7% in individuals with overweight and obesity (classes I and II) [96]. We hypothesized that individuals who have experienced discrimination might prefer seeking WLPs based on psychological rather than lifestyle features. Moreover, in our study, the *consequence module* was assigned to more men (12/39, 31%) than women (18/77, 23%), which appears to be in contrast to the results of the previously cited study that reported double the prevalence of weight-based discrimination in women [96]. The anonymity of a smartphone-based intervention combined with the opportunity to receive specialized psychological support targeted to individual needs could have been particularly appealing for men who had experienced weight-related discrimination and were affected by the consequences of their overweight. Nevertheless, the

module generally focused on weight-related emotional and physical consequences, which might be appealing to individuals with overweight and obesity regardless of whether they experienced discrimination.

Gender differences in health care services are an important consideration for the improvement of treatment outcomes [97]. Prior studies have indicated gender differences in eating behavior, as well as the psychological factors associated with weight gain and maintenance, highlighting the need for gender-targeted weight loss interventions [29,40]. As the effectiveness of gender dichotomous tailoring does not significantly differ from that of gender-neutral interventions [45], we implemented gender-sensitive self-tailoring features. The participants could choose between 2 gender-targeted versions at the beginning of the modules. The selection of the versions was heterogeneous, with most participants choosing women-targeted versions. This result supports the idea of gender-sensitive interventions to overcome gender binary [46]. However, its influence on the effectiveness of the intervention needs to be further investigated.

In complex digital interventions, the consideration of relevant process evaluation data (eg, usability testing and use patterns) is crucial before interpreting the effectiveness of the intervention [98]. The compliance with the app was satisfactory (90/109, 82.6%) and comparable with other studies. Signal et al [99] developed an eHealth intervention for prediabetes and diabetes self-management. They reported that 74% of the participants were actively engaged (ie, any use data were detected at any time throughout the 16-week intervention). Ruf et al [100] developed an mHealth intervention that assesses event-contingent dietary intake and physical activity, as well as relevant psychological parameters. Compliance, defined as the percentage of complete prompts within the total number of prompts received, was 80%. Another mHealth intervention focused on the management of food-related impulses to facilitate weight loss [101]. In that study, the completion rate (the number of participants who provided data at the 3-month follow-up) was 76%. These findings suggest that our compliance rate is comparable or even higher, although the differences in operational definitions cloud the interpretation.

Throughout the intervention, the use time and frequency decreased in both genders. Decreases in engagement were also reported in other studies; that is, in those with extended intervention periods [99,102]. Reductions in engagement and high dropouts are typical for internet-based interventions and are caused by a variety of reasons [103]. We hypothesized that the reduction in engagement observed in our study might be associated with the high number of competing commercial digital weight loss interventions, which might be less demanding, compared with psychological interventions. Moreover, the intervention phase of our study fell within the first and second lockdowns of the COVID-19 pandemic in Germany in 2020. During this period, the level of psychological distress increased, and vulnerable people engaged more often in dysfunctional eating patterns (ie, EE) [104]. In addition, many people were affected by short-term work or job losses and subsequent income losses [105]. It is likely that people neglected the intervention during this burdensome period.

The results from previous studies on the adherence to mHealth interventions are heterogeneous, with some reporting higher engagement in men [29,40,106] and others reporting higher engagement in women [99]. In our study, women used the app more frequently and spent more time on it. In the general German population, women report higher smartphone use time (mean 167 min/day) than men (mean 154 min/day), which might at least partially explain these differences [107]. Moreover, women are more interested in body appearance and health-related topics than men and use the internet more frequently for medical and health research [108-110]. Studies have also reported that women are more likely to use mHealth interventions focusing on nutrition and self-care apps, whereas men are more likely to use fitness apps [111-113]. Therefore, the lower engagement of the participating men in this study might be because the app focused on psychological rather than physiological determinants of overweight and obesity.

As reported in a recently published systematic review [114], other studies on mHealth interventions have either failed to report gender differences in the adherence to and usability of these interventions or reported results from biased samples with approximately 90% of women [115-117]. Given that higher engagement in mHealth interventions is usually associated with better outcomes [22,24,118], we propose that the samples in future studies should be more balanced with regard to gender and implement gender-sensitive feasibility and usability testing. Overall, the compliance with the app (90/109, 82.6%) and satisfaction with the app (86/100, 86%) were high and comparable with those of other mHealth interventions [99-101,119]. The usability of the app was rated with 71% (5.0/7.0 points) satisfaction. Other evidence-based mHealth weight loss interventions reported comparable or even lower usability scores, between 61.9% and 69.3% [100,119]. In addition, Ferrara et al [120] reviewed the usability of commercial weight loss apps, which can be downloaded from Google Play and the Apple Store. Scientists ranked the usability of these apps between 47% and 89%.

Limitations

In our study, men and women differed in the assignment of main modules, which focused on psychological parameters associated with the development and maintenance of overweight and obesity. Interestingly, most men and women selected the women-targeted versions of the main modules. Given that the participants were blind to the gender-targeted manipulation, we suggest that the selections were not influenced by social desirability. Future studies should distinguish between gender differences based on the results from explicit and implicit assessments to adjust for social norms. Moreover, the participants were forced to select one version at the beginning of each module and were not allowed to switch versions. A reasonable approach could be to allow participants to test both versions to enhance their adherence to the app. In addition, it should be verified whether the introductions of the versions sufficiently hint at different module content.

It should be noted that only few participants (41/109, 37.6%) evaluated the app after completion. The evaluation was voluntary and was assessed at the end of the last session of the

intervention. Therefore, results regarding satisfaction with the app and the main modules should be interpreted cautiously.

The results from the process evaluation revealed that men and women differed in their app use. Women used the app more frequently and longer than men. Most of the scientists involved in the development process were women. Therefore, the women-targeted features of the app might have been more salient and thus confounded the selection by both genders. This methodological aspect might subsequently explain the higher use patterns of the participating women. Future studies or revisions of the app intervention should involve men scientists.

Conclusions

In summary, given the high diversity in module assignment, we hypothesize that tailoring was successfully implemented in the intervention. The heterogeneous selection of the gender-targeted features might underscore the need for gender-sensitive (self-tailoring and blind choice) instead of gender dichotomous (computer-based tailoring) targeting but could also hint at methodological limitations, which need to be considered and further investigated in future studies. Further studies need to clarify whether the reported gender differences in the use and evaluation of the app confound the effectiveness and sustainability of the I-GENDO intervention.

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Authors' Contributions

MP was involved in conceptualization, the acquisition of data, formal analysis, the interpretation of data, and the writing of the original draft. TF was involved in the acquisition and interpretation of data, review, and editing. CS and TR were involved in the acquisition of data, review, and editing. SS contributed to the study design. JW and SH contributed to the study design, supervision, review, and editing. SS-L contributed to the study design, conceptualization, study supervision, review, and editing.

Conflicts of Interest

None declared.

Multimedia Appendix 1

Evidence, content, and adaptions of the gender-sensitive main modules.
[DOCX File , 55 KB-Multimedia Appendix 1]

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Abbreviations

EE: emotional eating
FA: food addiction
IPQ-R: revised illness perception questionnaire
mHealth: mobile health
WLP: weight loss program

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TITLE PAGE

Title

Differential Effects of the Individualized Gender-Sensitive mHealth Intervention I-GENDO on Eating Styles in Individuals with Overweight and Obesity – A Randomized Controlled Trial

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ABSTRACT

Background

Addressing cognitive behavioral factors in digital obesity treatment is associated with a favorable development of weight and health behavior. Research indicates various gender disparities in these psychological aspects. This randomized-controlled trial aimed to evaluate the effectiveness of the self-guided gender-sensitive mHealth intervention I-GENDO on eating styles, BMI, and physical activity at the end of the intervention, and at a 9- and 15-month follow-up.

Methods

213 individuals (67% female, BMI: 33.35 ± 3.79 kg/m^2) were randomly assigned to the intervention or control group. Multilevel models were calculated to investigate differences between groups. I-GENDO offered interactive modules addressing psychological content associated with obesity. Users were able to self-tailor intervention content based on their individual needs and life realities.

Results

Restrained eating was higher in the intervention group after the intervention (95% CI: 0.20, 0.36), at 9- (95% CI: 0.07, 0.24) and 15-months (95% CI: 0.04, 0.22). Emotional eating decreased in women at 9-months (95% CI: -0.44, -0,19) but was not sustained at 15-months. In the intervention group, external eating was lower after the intervention, which remained significant for women at 9 (95% CI: -0.40, -0.19) and 15-months (95% CI: -0.34, -0.13). BMI of men in the intervention group was 1.44 lower at 15-months than in the control group. No significant effects on physical activity were found.

Conclusions

The I-GENDO intervention was effective in changing restrained eating of women and men in the long-term, suggesting that a self-guided, gender-sensitive approach is promising. However, the differential effects on the outcome measures indicate that more research is warranted to examine distinct gender-sensitive mechanisms of digital psychological interventions (i.e., dose-response relationship, blended counselling).

Registration

ClinicalTrials.gov identifier: NCT04080193, https://clinicaltrials.gov/ct2/show/NCT04080193

Keywords

obesity, overweight, mHealth, digital health, psychology, cognitive behavioral therapy, gender

BACKGROUND

A constant increase in body weight has been observed over the last few decades. Global prevalence rates estimate that in 2015, 1.9 billion adults worldwide were classified as overweight (Body Mass Index, BMI: 25.00 – 29.99 kg/m^2) of which 609 million were affected by obesity (BMI ≥ 30.00 kg/m^2) [1]. The prevalence of overweight is approximately similar for women (38%) and men (37%), but women are more often affected by obesity (15%) than men (10%) [2]. Obesity is associated with numerous adverse physical, psychological, and behavioral health outcomes. In addition to the short- and long-term physical health risks [3], individuals with overweight and obesity are at higher risk to experience adverse mental health outcomes such as depression and anxiety, lower self-esteem, body dissatisfaction, and self-efficacy [4, 5].

Compared with normal weight controls, individuals with overweight and obesity tend to show lower levels of physical activity [6] as well as diverging expressions of eating styles [7, 8]. Eating styles, such as restrained, emotional and external eating, are considered important aspects for weight loss and weight loss maintenance [9]. Thus, restrained eating [10], that is, restricting food intake because of weight concerns, facilitates successful weight loss and weight loss maintenance [11]. In contrast, higher levels of reported emotional eating [10], that is, eating because of emotional states, such as anger or sadness, seem to present a barrier to weight loss [12–14] and pose a risk factor for weight regain after treatment [15]. The findings are inconclusive in studies investigating the impact of external eating [10], that is, eating because of external cues such as the sight or smell of food. Some studies found high external eating to be a barrier for long-term weight changes [16, 17], whereas some authors state that the extent of the influence of external eating on weight development is negligible [18].

All these eating styles are associated with different cognitive, emotional and behavioral abilities. For example, to successfully engage in restrained eating, a certain degree of self-control [19] and self-efficacy [20, 21] is necessary. Emotional eating often results from a lack of alternative coping strategies or emotion regulation skills needed for dealing with negative emotions or stressful situations [22–24]. To be able to

77 regulate nutrition intake based on physiological internal (i.e., hunger, satiety) instead of external cues (i.e.,
78 time of day, smell of a certain food), the ability to identify the underlying motivation for eating as well as a
79 certain degree of food-related inhibitory control is needed [25, 26].
80 Studies comparing individuals with overweight with normal weight counterparts have shown that the
81 psychological abilities described above differ between these two groups. More specifically, individuals with
82 overweight show deficits in inhibitory control [27], emotion regulation, and interoceptive awareness [28].
83 Moreover, an enhanced reactivity to food cues is prevalent in this group [29]. These underlying
84 psychological abilities can be addressed and augmented through treatment components of cognitive-
85 behavioral therapy (CBT) for obesity, such as emotion regulation skills training, problem solving, cognitive
86 restructuring, stimulus control training, and mindfulness interventions [30]. Implementing CBT is
87 associated with short-term weight loss [31] and a favorable development of eating styles [32–34].
88 Cognitive-behavioral factors leading to and maintaining excess weight can strongly vary between
89 individuals. A growing body of research suggests gender disparities in weight-related attitudes and
90 psychological mechanisms arising from sociocultural and behavioral aspects of overweight that differ
91 between gender [35–38]. For example, women are more likely to perceive themselves as overweight [39]
92 and to experience higher levels of internalized weight bias [40], whereas men tend to have an inaccurate
93 weight perception [38]. Furthermore, rumination is more frequently associated with women [41] and
94 thought suppression with men [42], both characterizing unfavorable cognitive emotion regulation strategies
95 for the development of problematic eating behaviors. Therefore, gender-specific needs and life-realities
96 need to be identified and integrated into treatment of obesity to target intervention content and enhance
97 efficacy.
98 Such individualization can be implemented through mobile health (mHealth) approaches [43] that enable
99 self-tailoring (i.e., users actively select the content that matches their preferences and needs) and computer-
100 based tailoring (i.e., an algorithm selects content based on an assessment of user characteristics or attitudes)
101 of content [44–46]. mHealth interventions have been shown to be effective as a treatment option for obesity
102 [47]. They present an effective way to provide low-threshold, personalized treatment solutions that deliver

a combination of multiple evidence-based treatment components [48]. To date, most mHealth research focuses on changes in weight and total nutrition or calorie intake [49, 50]. Eating styles are often examined as relevant outcome measures or mediator variables for weight management in experimental and face-to-face studies, but mHealth studies investigating the development of eating styles in obesity interventions are lacking. Therefore, we examined whether an mHealth intervention influences these eating styles in a similar fashion.

Against this background, the aim of the I-GENDO project was the development and evaluation of a gender-sensitive individualized psychological multi-component mHealth intervention with self-tailoring and computer-based tailoring elements [51, 52]. The 12-week intervention was delivered via a smartphone app focusing on psychological aspects associated with eating styles. The app provided gender-sensitive CBT components within seven modules: goal setting and motivation, stress management skills, emotion regulation skills, dealing with consequences of overweight, self-efficacy, self-regulation skills, and relapse prevention. The technical capabilities of I-GENDO allowed users to adapt treatment content individually to their gender-specific needs. The study aimed to not only achieve short-term improvements in weight related behavior (i.e., eating styles, physical activity) but also to facilitate long-term behavior change by implementing beneficial psychological strategies through an individualized gender-sensitive treatment approach.

The efficacy of the I-GENDO app was evaluated in a randomized controlled trial (RCT) with with a post assessment and two follow-ups at 9 and 15 months. The primary aim was to examine the development of restrained, emotional, and external eating (primary outcomes) over the course of the intervention and follow-up period. In the intervention group, we expected a greater decrease in emotional and external eating and an increase in restrained eating compared to the control group. Furthermore, we assumed long-term improvements in physical activity levels and a decrease in BMI in the intervention group compared to the control group (secondary outcomes). Gender was considered in all analyses on an exploratory level.

METHODS

The study is reported in line with the CONSORT reporting guidelines (53; Additional File 1).

Study Design

The efficacy of I-GENDO was assessed in a RCT (NCT04080193) with a wait-list control condition. Data was collected before the onset of the I-GENDO intervention (baseline), at 3 months (end of intervention), 9 months (follow-up 1) and 15 months (follow-up 2) after baseline. At each of these four assessments, participants answered an extensive online questionnaire and wore an accelerometer for seven consecutive days. The study was carried out in accordance with the Declaration of Helsinki. The Ruhr-University Bochum Institutional Review Board (No. 18-6415) as well as the ethics committee at the University of Bamberg approved this study. All participants were informed about the study and provided informed consent.

Participants

Participants were recruited from August 2019 to August 2020 via study flyers, newspaper articles, social media, radio features, and oral presentations at rehab centers and clinical facilities. Participants interested in study participation were asked to complete an online survey to assess inclusion criteria and screen for exclusion criteria.

Participants were included if they a) were at least 18 years old; b) had a BMI between 30.00 and 39.99 kg/m² or a BMI between 25.00 and 29.99 kg/m² with weight-related health problems (e.g., type 2 diabetes, hypertension) or psychosocial distress; c) had access to a smartphone; d) were able to read, write and speak in German; and e) were motivated to lose weight. Exclusion criteria were a) current pregnancy; b) current (or within the last 12 months) involvement in a structured psychological weight loss program; c) current psychotherapeutic treatment of weight-related problems; d) previous or intended bariatric surgery; e) current regular intake of drugs that influence weight; f) untreated weight-related health problems; g) current substance abuse, major depression or suicidal ideation; h) binge-eating disorder or bulimia nervosa according to DSM-5 criteria; and i) severe cognitive impairments. In case of reported suicidal intentions assessed with the PHQ-9 [54] or suspected eating disorder assessed with the Munich ED-Quest [55],

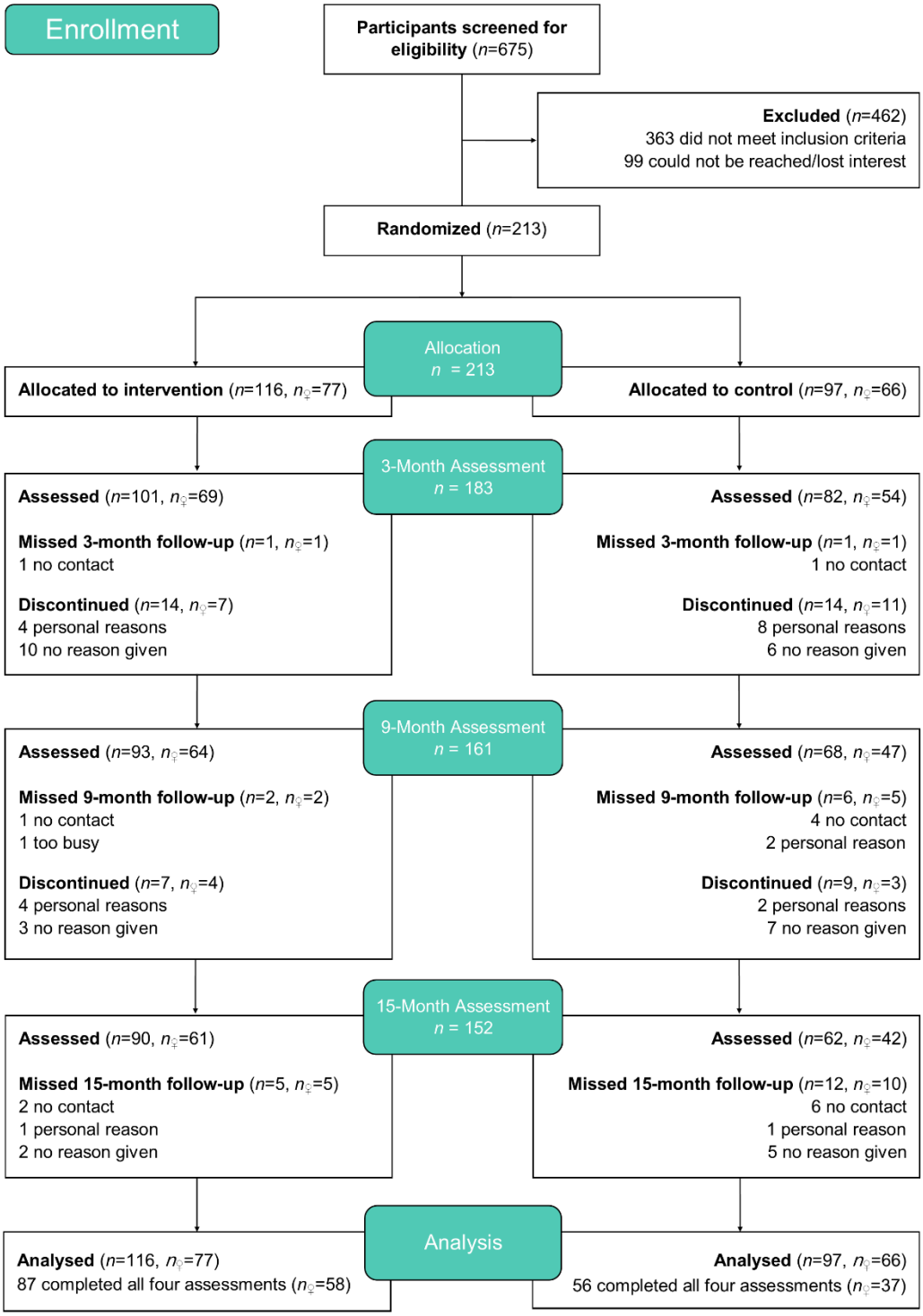
individuals were contacted via phone and subsequently diagnosed with structured interviews by experienced psychologists and eventually referred to suitable support services.

A total of 675 individuals completed the survey, of which 363 were excluded because they met at least one exclusion criterion, and 99 individuals could not be reached or lost interest in study participation. Finally, 213 eligible participants were included in the study. All participants were randomly assigned to one of the study arms, stratified by gender: I-GENDO intervention (n = 116) or control condition (n = 97), using a computerized electronic random number generator. The majority of the participants identified themselves as female (n = 143), 70 as male, and none as third gender.

An a priori power calculation revealed the need for n = 64 participants per group to discover a medium effect of group differences ($\alpha = .05$, $1\text{-}ß = .80$). Dropout rates of 10% for each of the four assessments were expected, leading to a total of N = 214 participants needed to be recruited. We initially obtained 214 randomized participants, but one person withdrew from the study and requested deletion of data, resulting in a final analytic sample of 213 participants. See Figure 1 for the CONSORT flow diagram.

*** PLACE FIGURE 1 AROUND HERE ***

Figure 1. CONSORT flow diagram of the randomized controlled trial.



Procedure

Participants were invited to an in-person appointment at the study site in Bochum or Bamberg, Germany, where they received instructions about the procedure of the trial, installed the I-GENDO app on their

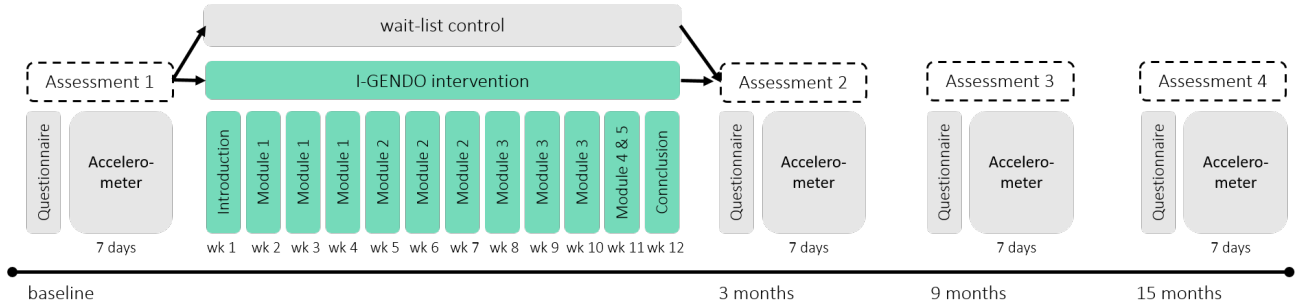
personal smartphones (iOS or Android operating systems), answered questionnaires and received an accelerometer. Study staff was blinded to the group allocation of participants.

Participants were instructed to wear the accelerometer for seven consecutive days. After this assessment period, they were informed about their group allocation by e-mail. The interface of the app automatically switched from assessment mode (i.e., self-monitoring) to the control (i.e., number of days until the second questionnaire is available) or intervention (i.e., number of days until the intervention content is available) mode. On the next following Monday, the I-GENDO intervention was released to the intervention group. Participants in the control group received no intervention. After 3 months, both groups received the invitation to the second questionnaire, and the app interface switched back automatically to the assessment mode for all participants, based on their individual start day. Given the restrictions caused by the COVID-19 pandemic, no further in-person assessments could be conducted. Therefore, participants received instructions by phone or mail, and accelerometers for the 7-day assessment period were sent by mail. This procedure was identical for the 9- and 15-month follow-up assessments (Figure 2).

All participants received a monetary compensation of a maximum of 100€ for each of the four assessments resulting in a maximum of 400€ each (30€ for completing the questionnaire, 10€/day for wearing the accelerometer for at least 10 hours). Participants in the control group were granted access to the I-GENDO intervention after completion of their last assessment (15 months after baseline).

*** PLACE FIGURE 1 AROUND HERE ***

Figure 2. Intervention procedure and assessments.



Intervention

The I-GENDO app is a 12-week self-guided multicomponent mHealth intervention that offered an individualized training program with seven modules primarily based on a CBT approach. The personalized assignment of the modules was based on the illness perceptions of each participant, measured by an adapted German version of the Illness-Perception Questionnaire (IPQ-R; 56, 57). Individualization was implemented through self- and computer-based tailoring features (for a detailed description, see 51).

The modules focused on different cognitive, emotional, and behavioral aspects related to weight loss management. These were a) goal setting and motivation; b) stress management skills; c) emotion regulation skills; d) dealing with consequences of overweight such as stigmatization and body dissatisfaction; e) self-efficacy; f) self-regulation skills; and g) relapse prevention. The modules were each offered in a female-targeted and a male-targeted version, which differed in terms of prioritization of topics, knowledge transfer, and communication style [51]. This gender-sensitive approach was implemented to increase the relevance and appeal of each topic to all participants. The training sessions within each module contained psychoeducational elements delivered through texts and videos and instructions for self-reflective and practical exercises (i.e., mindfulness exercises, behavioral rehearsal, self-monitoring of behavior, and social support). The modules were unlocked continuously over the course of 12 weeks. Additionally, the app included optional functions such as self-monitoring, homework sessions, and a toolbox to save favored items.

Measures

Questions about age, gender, and anthropometry (i.e., weight, height) were included in the online questionnaires. BMI was calculated by dividing the reported body weight in kilograms by height in meters squared.

Eating styles

The German version of the Dutch Eating Behaviour Questionnaire (DEBQ; 10, 58) was used to assess eating styles. The questionnaire consists of 30 items with three subscales: emotional eating (i.e., eating because of different emotional states, such as anger or sadness), restrained eating (i.e., restricting food intake because

of weight concerns) and external eating (i.e., eating because of external cues, such as the sight or smell of delicious food). Participants recorded their degree of agreement to each statement from 1 (never) to 5 (very often). Mean scores for each subscale were calculated. Higher values indicate a stronger expression of the corresponding eating style.

Device-based measured physical activity

Physical activity (i.e., step count) was measured continuously over the course of the four 7-day assessment periods using the tri-axial ActiGraph® wGT3X-BT accelerometer (firmware v1.9.2, ActiGraph, Pensacola, FL, USA), which was attached to an elastic waist belt. Participants were instructed to position the sensor on the right hip, which was found to be a good placement for the assessment of everyday physical activity [59]. Participants were instructed to wear the accelerometer during waking hours for seven consecutive days and to only take it off while showering or participating in other water-related activities. Raw data was sampled at an input frequency of 30 Hz and initially stored on the device. The ActiLife® software (version 6.13.4; ActiGraph, Pensacola, FL, USA) was used to process the raw data into meaningful step count. Participants were required to provide at least 10 hours of wear time per day (valid day) for at least four days in each assessment week to be included in the analysis. Average step count per day was calculated by dividing the total amount of steps of valid days by the number of valid days.

Statistical Analyses

Descriptive analyses were conducted using percentages and frequencies for categorical variables, as well as means and standard deviations for continuous variables. Comparisons of socio-demographic variables and baseline values between the intervention and control group and between male and females within each group were tested using chi-square distributions (categorical) and analyses of variance (ANOVA; continuous variables). Linear multilevel regression models were estimated using maximum likelihood to analyze the impact of the intervention (i.e., I-GENDO, control), time (i.e., baseline, 3, 9 and 15 months), gender (female, male) and the intervention-by-time interaction. A two-level model structure including a random intercept was applied. Five separate models were calculated with the outcome variables restrained, emotional, and external eating and BMI and step count. All reported models were adjusted for the baseline value of the

outcome variable (see Additional File 2 for models without adjustment of baseline values). Mean values of each outcome were estimated at 3, 9 and 15 months for both groups and differences between the intervention and control group were calculated.

To test for potential effect modification by gender, group*time*gender interaction terms were added to the models, and the interaction term remained in the final model when significant interactions with gender were detected, and estimates were reported separately for men and women. Intraclass correlation coefficients (ICCs) of the null models indicated that 62% (restrained eating), 79% (emotional eating), 75% (external eating), 91% (BMI), and 62% (step count) of the differences were due to between-person effects.

SPSS 28 (IBM Corp, Armonk, NY, USA) and different packages of R (R Core Team, 2021) and Rstudio (Rstudio Team, 2021) were used for all analyses. The 'ggplot2' package (v 3.3.5) was used for visualizations (Wickham, 2016), multilevel models were calculated using the 'nlme' package (v. 3.1 – 155; Pinheiro et al., 2022), and model assumptions were checked using the 'performance' package in R (c. 0.8.0; Lüdecke et al., 2021). The results tables of the regression analyses were generated using the 'sjPlot' package (v 2.8.10; Lüdecke, 2021). Level for significance was set a priori to $p < .05$. For the interactions, a p value of <.10 was considered statistically significant.

RESULTS

No significant baseline differences in sociodemographic variables between the two study groups were detected (Table 1). However, women in the control group were significantly younger than men in the control group ($F(1, 209) = 7.07$, $p = .008$, partial $\eta^2 = .033$) and women in the control and intervention group reported significantly higher scores on the emotional eating scale than male participants in the respective groups ($F(1, 209) = 14.40$, $p < .001$, partial $\eta^2 = .064$). Significantly more individuals in the intervention group ($n = 87$) completed all four assessments than in the control group ($n = 56$; $\chi^2(1) = 6.38$, $p = .012$).

*** INSERT TABLE 1 AROUND HERE **

Table 2 displays the model-estimated means, standard errors, 95% confidence intervals (CI) and between-group difference at 3, 9 and 15-month assessments adjusted for baseline value from fitted maximum likelihood repeated measures mixed models for the self-reported outcomes.

*** INSERT TABLE 2 AROUND HERE ***

At the 15-month assessment, individuals in the intervention group reported higher scores for restrained eating than participants in the control group ($\beta = 0.23$, $p = .069$). The same pattern was found at both previous assessments (3 months: $\beta = 0.47$, $p < .001$; 9 months: $\beta = 0.26$, $p = .033$). As shown in Table 2, the difference was 0.28 at 3 months and decreased towards 0.13 at 15 months, although remaining statistically significant. We found no gender differences in intervention effects.

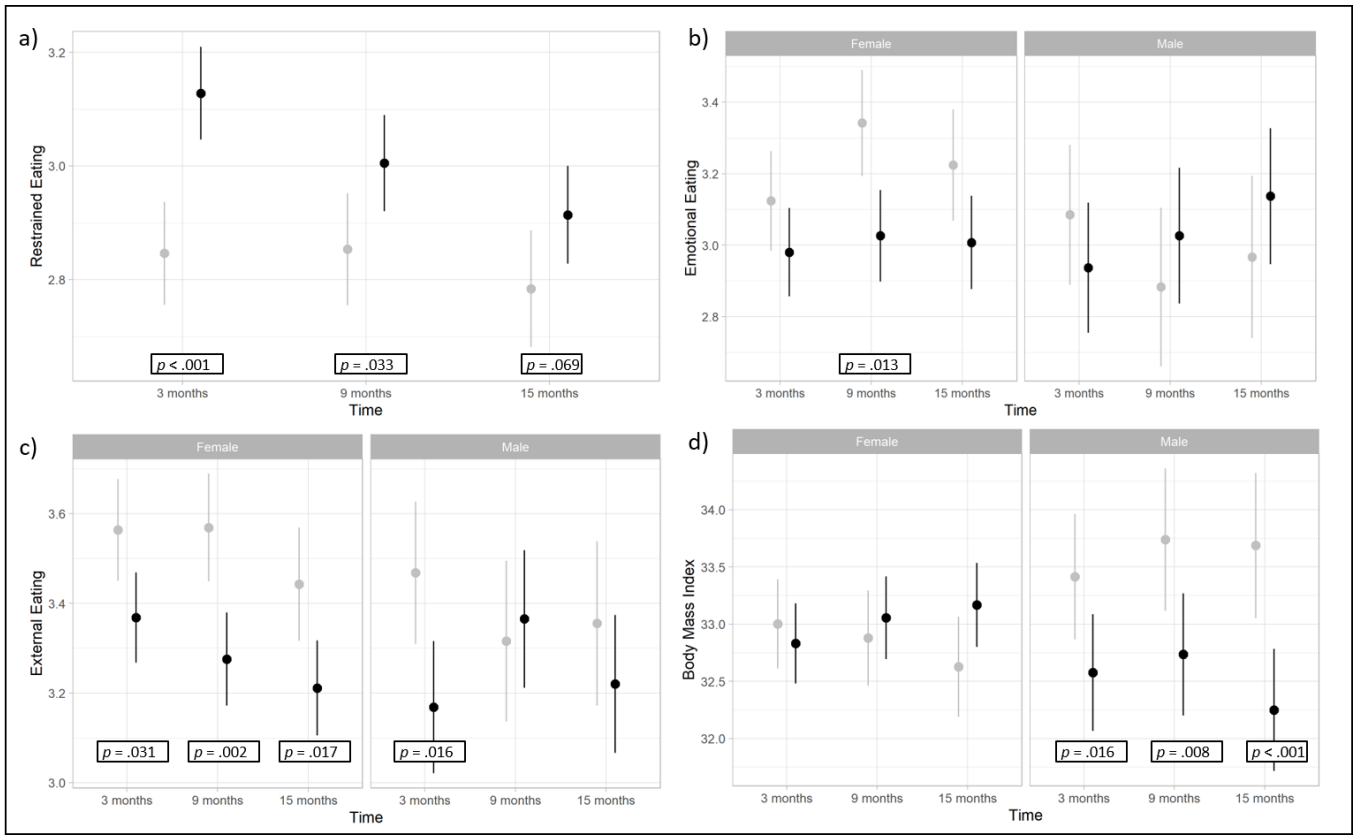
A gender-specific effect of the intervention was found for emotional eating, as indicated by a significant interaction between group, time, and gender. Women in the intervention group reported significantly lower emotional eating at the 9-month assessment compared to women in the control group (difference 0.28, 95% CI: 0.20, 0.36). No significant differences were found immediately after the intervention (3 months) or in the long-term (15 months). Men reported no significantly different values across groups at any assessment, indicating that the intervention had no significant effect on emotional eating in men.

Women and men in the intervention group reported significant lower levels of external eating than participants in the control group. Females in the intervention group reported decreased levels of external eating in comparison to the women in the control group at the end of the intervention (difference at 3 months: -0.20, 95% CI: -0.30, -0.10) and at follow-up (difference at 9 months: -0.29, 95% CI: -0.40, -0.19; difference at 15 months: -0.23, 95% CI: -0.34, -0.13). In males, external eating was only significantly lower in the intervention group immediately after receiving the intervention (difference at 3 months: -0.30, 95% CI: -0.45, -0.15).

Compared with the control group, the assignment of the intervention resulted in a statistically significant long-term weight loss for men (difference at 15 months: -1.44, 95% CI: -1.97, -0.91). Immediately after the intervention the difference was -0.84 (95% CI: -1.35, 0.33) and increased to -1.00 BMI points (95% CI: -1.54, -0.47) at 9 months. The intervention had no significant effect on women's BMI. Figure 3 displays the between-group differences for each outcome at each assessment.

*** INSERT FIGURE 3 AROUND HERE ***

Figure 3. Intervention effect for each outcome at each assessment.



Legend. Between-group differences (black = intervention group, gray = control group) adjusted for baseline value for a) restrained eating, b) emotional eating, c) external eating, d) BMI at each assessment for each gender. Significant interactions are indicated by the p value.

No baseline adjusted differences between men and women at 3 (74.64, 95% CI: -460, 609), 9 (230, 95% CI: -147, 608) and 15 months (277, 95% CI: -91, 646) were found between the intervention and control group for step count, indicating that the intervention had no effect on this physical activity measure (Additional File 3).

DISCUSSION

The aim of this RCT was to investigate whether a gender-sensitive psychological mHealth intervention based on CBT improves eating styles by addressing the underlying psychological skills. Overall, our mHealth intervention achieved favorable long-term (15 months) changes in restrained eating for women and

men and in external eating for women. Additionally, the I-GENDO intervention led to a statistically significant decrease in men's BMI.

Restrained Eating

Our results show that men and women in the intervention group, compared to controls, showed improvements in restrained eating immediately after the intervention (three months after baseline), which were also observed at follow-up (9 and 15 months after baseline). This result is promising because in face-to-face intervention studies increased levels of restrained eating are known to be predictors of weight loss and weight loss maintenance [11] and related to long-term success [60]. Research also shows that restrained eating has a preventive effect on weight gain, even when eating habits that are normally associated with weight gain are prevalent, for example, loss of control eating [18].

Bijholt and colleagues [61] investigated women during the postpartum period with a history of excessive gestational weight gain using the INTER-ACT mHealth intervention in combination with face-to-face contact. They also found a favorable increase of restrained eating, but the effect was only short-term immediately after the intervention and was not evident at the 6 month follow-up [61]. In our study, the effect was still present at 15 months, and it was also present in men. While the general principles of the INTER-ACT intervention were goal setting and motivational tips [62], the I-GENDO intervention included highly interactive and cognitive demanding content for knowledge acquisition, self-reflection, and exercises for knowledge transfer. These behavior change techniques and components of CBT are also implemented in effective face-to-face studies addressing eating styles [34]. Overall, increasing restrained eating plays an important role in conventional obesity treatments, and we showed that these sustained effects can also be reached by using our I-GENDO mHealth intervention.

Emotional Eating

Contrary to assumptions, the I-GENDO intervention elicited no long-term changes in emotional eating in either men or women. We only observed an effect after 9 months in women, which was not maintained at 15 months. This was unexpected because emotional eating is associated with a decreased ability to regulate emotions [63], and the intervention content was specifically designed to empower the participants to identify

unfavorable emotion regulation strategies (i.e., eating to suppress feelings, rumination) and to adapt and build substantial emotional competences.

These findings may be related to the challenges posed by the digital implementation of emotion regulation strategies. CBT has been shown to be effective in the treatment of obesity in face-to-face settings [32]. Therefore, the I-GENDO intervention included several evidence-based CBT principles that targeted emotional competences (i.e., identify warning signs, build helpful habits, problem solving, and relaxation). Studies investigating the effects of self-guided digital interventions in non-clinical samples showed that the digital adaptation of CBT successfully led to favorable changes in stress, mindfulness, and eating behaviors [64, 65]. Nevertheless, a lack of studies have validated the effectiveness of CBT strategies that target emotion regulation in mHealth programs for the specific target group of individuals with overweight and obesity [66, 67]. Therefore, we question whether a self-guided mHealth environment represented a feasible approach to substantially change emotional processes in emotionally burdened individuals as in the present sample. These considerations are particularly reasonable in light of the fact that meaningful differences in restrained eating were elicited by the I-GENDO intervention. In such conditions, the cognitive approach of an mHealth intervention may be more suitable because restrained eating behavior is associated with predominantly cognitive processing (i.e., goal activation) and executive functions (i.e., inhibition control) [68, 69]. Thus, we assume that to significantly change emotional strategies an individualized blended intervention approach or even a face-to-face setting is needed.

Another possible explanation for the lack of long-term changes in emotional eating might be that participants differ in the level of knowledge and awareness about the effects of emotions on eating. Thus, participants who have less access to their emotions might need more support and time gaining insight into emotions and possibly need more time practicing new emotion regulation skills, whereas those aware of their emotions and individual emotion-regulation skills could find cognitive restructuring more helpful [70]. A noteworthy consideration is that the time and dose offered by the I-GENDO intervention was not sufficient to change emotional processes. Our results suggest that access to own emotions, emotion regulation strategies already used, and the degree of trait emotional intelligence should be assessed before the beginning of the

intervention [22]. The intervention should then be adapted accordingly to the affect-related psychological needs of the person.

External eating

The intervention was effective for female participants immediately after the intervention and at the 15-month assessment compared to the control group. In contrast to our expectations, we observed an intervention effect for male participants only immediately after the intervention, not at the 15-month follow-up. A pronounced external eating style is associated with a reduced ability to perceive internal bodily cues (i.e., hunger, satiety) [71] and a higher attentional bias for food cues [25, 72]. Furthermore, external eating is associated with overconsumption [18], binge eating [73], and food craving [17].

A review of mHealth interventions in obesity treatment that focus on changing external eating showed that such interventions focus predominantly on promoting mindfulness-based eating awareness. This strategy is considered as an antagonist of external eating because it represents the ability to perceive internal signals (i.e., hunger, satiety) and to guide eating behavior accordingly [74]. The main criticism of the reviewed studies was that the key features of the apps (i.e., eating timers, hunger rating apps, diaries) were not sufficient to establish a mindfulness-based eating style. In contrast, our multibehavioral I-GENDO intervention offered more comprehensive and diverse features developed to teach mindful eating as an alternative strategy to external eating (i.e., guided eating meditations, strategies involving the five senses, integration of mindfulness into daily life). These aspects might explain why participants in our study had favorable values in external eating immediately after the end of the intervention. However, an interesting finding is that the effect was not maintained for men. We assume that women benefitted in the long-term because they might have adopted the strategies and mindset into their everyday life. This is reasonable since research indicates that women tend to benefit more from mindfulness interventions than men [75].

BMI and physical activity

Our intervention led to a small but sustained BMI decrease in men, which was statistically significant but not clinically relevant (< 5% weight loss). Furthermore, we found no improvements in physical activity in the intervention group for men and for women. The I-GENDO intervention primarily sought to change

psychological aspects of eating behavior and eating styles. We had no assumptions that our intervention would have a short-term impact on weight or exercise behavior because we prescribed no specific nutritional or activity recommendations (such as low-fat diet or minimum step count). However, we assumed that BMI would decrease and that physical activity would increase in the long-term. We hypothesized that learned psychological skills and strategies such as goal setting might also affect physical activity and that improving eating styles would also affect weight development, but we found no evidence for these effects. Apparently, working primarily on psychological factors associated with weight management had no clinically relevant effect on BMI or physical activity in the long-term. However, mHealth studies that have provided specific behavioral instructions also show only ambiguous or inconsistent results on the clinical relevance of weight loss or long-term effects [76].

Perhaps an mHealth intervention would be more beneficial on the BMI or physical activity, if an individualized CBT-based mHealth approach was combined with concrete behavioral suggestions such as calorie restrictions or a daily exercise goal. Just-in-time-interventions that offer treatment strategies tailored to the actual behavior show promising results for increasing physical activity [77]. However, a stand-alone self-guided mHealth intervention might not be sufficient enough to substantially change behavioral outcomes and perhaps should therefore be combined with traditional face-to-face approaches.

Limitations and strengths

Our study has some noteworthy limitations. First, the significant differences in attrition rates between the control and intervention group represent a weakness of the study (dropout rates: 42% vs. 25%). Although participants in the control group were given access to the app after the end of the study, and the financial incentives were the same for both groups, being assigned to the control condition during this phase of behavior change (i.e., motivation to lose weight, high expectancies) could have understandably elicited frustration and contributed to a higher dropout. This phenomenon has also been observed in comparable mHealth RCTs [78]. We considered these differences by implementing a multilevel model approach, which is robust to the biases of missing data and represents an intention-to-treat approach [79]. Second, our app allowed users to independently select one of two gender-specific variants for each module and was thus

gender-sensitive (self-tailoring). Although this innovative technological approach is very promising because of the established sex differences in obesity treatment, the lack of a comparison group with a non-gender-sensitive app precludes the conclusion that this gender-sensitive structure contributed to greater effects. This comparison still needs to be verified in future studies.

A strength of the current study is that the development of the I-GENDO intervention was guided by a participative and iterative research process, actively involving patients as well as experts in the treatment of obesity. Overall, the intervention was well received by the participants [51] and compared to other lifestyle mHealth self-monitoring intervention groups (range: 5% - 55%), we observed a relatively low drop-out rate in the intervention group (25%) by the 15 month [80]. Most interventions in obesity treatment do not take different gender preferences into account [81]. Therefore, we developed a gender-sensitive, computer- and self-tailored intervention, which reflects an attempt to integrate a gender-sensitive approach. Our results show that we succeeded in designing a self-guided mHealth approach, that targets women and men, which results in differential but favorable effects for both genders.

CONCLUSION

This study demonstrated that the gender-sensitive multi-component self-guided mHealth intervention I-GENDO provides long-term benefits from restrained eating for women and men with overweight and obesity who are motivated to lose weight but not from emotional eating and only beneficial changes in external eating for women. We assume that restrained eating might be feasible to target with a CBT-based mHealth approach because it is associated with more cognitive processes that can be implemented and modified in a self-guided matter. In contrast, emotional processes that are associated with emotional eating might be better addressed via blended counseling approaches because they allow a more profound examination and interaction with these topics in face-to-face settings. For BMI and physical activity, the stand-alone I-GENDO intervention elicited no clinical meaningful effects. Therefore, we recommend our gender-sensitive mHealth intervention especially when the focus is on changing restrained eating behavior (i.e., individuals with decreased food-related inhibitory control). For further outcome measures associated with weight management, like emotional eating, BMI, and physical activity, our app is not sufficient alone

and can therefore be recommended as a valuable add-on treatment in combination with a face-to-face intervention.

DECLARATIONS

Ethical approval and consent to participate

The study was carried out in accordance with the Declaration of Helsinki. The Ruhr-University Bochum Institutional Review Board (No. 18-6415) as well as the ethics committee at the University of Bamberg approved this study. All participants were informed about the study and provided informed consent.

Consent for publication

Not applicable

Availability of data and materials

The intervention content used and the datasets analysed during the current study available from the corresponding author on reasonable request. Analysis code is available at the Open Science Framework (https://osf.io/r4p9d/#).

Competing interests

The authors declare that they have no competing interests.

Funding

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Authors' contributions

CS, TF, MP, SS, JW, SSL, and SH designed the study. CS, TF, and MP collected the data, and formulated the study question. CS, TF and AD performed the data analysis, data interpretation, and generation of figures and tables. JW was responsible for preparing the accelerometer data for statistical analysis. CS, TF, and JW

drafted the manuscript. MP, AD, SH, and SSL contributed to the final version of the manuscript. All authors read and approved the final manuscript.

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Authors' information

Not applicable

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Table 1. Baseline characteristics

Variables	Overall		Control		Intervention	
	Control (*n* = 97)	Intervention (*n* = 116)	Female (*n* = 66)	Male (*n* = 31)	Female (*n* = 77)	Male (*n* = 39)
Demographics						
Age (in years); *M* (*SD*)	45.45(12.66)	47.27(11.65)	43.24(12.86)	50.16(11.00)	46.40(12.22)	49.00(10.38)
High School Degree; *n* (%)	25(25)	36(31)	17(26)	8(26)	25(32)	11(28)
Married or living with a partner; *n* (%)	79(81)	91(78)	52(79)	27(87)	57(74)	34(87)
Weight and body composition						
Weight (in kg); *M* (*SD*)	97.65(14.84)	98.34(15.39)	94.24(13.43)	104.90(15.31)	93.44(12.56)	108.03(16.02)
BMI (in kg/m^2); *M* (*SD*)	33.07(3.79)	33.58(3.79)	33.23(3.74)	32.72(3.92)	33.75(3.69)	33.23(4.02)
Eating Styles						
Restrained Eating; *M* (*SD*)	2.80(0.58)	2.70(0.58)	2.83(0.58)	2.75(0.58)	2.78(0.55)	2.55(0.62)
Emotional Eating; *M* (*SD*)	3.12(0.95)	3.05(1.03)	3.36(0.86)	2.59(0.94)	3.30(0.95)	2.57(1.02)
External Eating; *M* (*SD*)	3.47(0.62)	3.48(0.67)	3.54(0.65)	3.33(0.54)	3.52(0.66)	3.42(0.71)
Physical activity[1]						
Step count per day; *M* (*SD*)	7296(3020)	6831(2251)	7196(2756)	7505(3559)	6765(1965)	6966(2776)

[1] *n* = 194

Table 2. Model-estimated means, standard errors, and 95%CI for all outcomes at 3, 9 and 15 months

	3 months							9 months							15 months						
	Control			Intervention			Between-group difference [95% CI]	Control			Intervention			Between-group difference [95% CI]	Control			Intervention			Between group difference [95% CI)
	Mean	SE	95% CI	Mean	SE	95% CI		Mean	SE	95%CI	Mean	SE	95%CI		Mean	SE	95%CI	Mean	SE	95%CI	
Restrained																					
Overall	2.85	0.05	[2.76, 2.94]	3.13	0.04	[3.05, 3.21]	**0.28 [0.20, 0.36]**	2.85	0.05	[2.76, 2.95]	3.00	0.04	[2.92, 3.09]	**0.15 [0.07, 0.24]**	2.78	0.05	[2.68, 2.89]	2.91	0.04	[2.83, 3.00]	**0.13 [0.04, 0.22]**
Emotional																					
Male	3.09	0.10	[2.89, 3.28]	2.94	0.09	[2.76, 3.12]	-0.15 [-0.33, 0.03]	2.88	0.11	[2.66, 3.10]	3.03	0.10	[2.84, 3.22]	0.14 [-0.05, 0.33]	2.97	0.12	[2.74, 3.19]	3.14	0.10	[2.95, 3.33]	0.17 [-0.02, 0.36]
Female	3.12	0.07	[2.98, 3.26]	2.98	0.06	[2.86, 3.10]	-0.14 [-0.27, -0.02]	3.34	0.08	[3.19, 3.49]	3.03	0.07	[2.90, 3.15]	**-0.32 [-0.44, -0.19]**	3.22	0.08	[3.07, 3.38]	3.01	0.07	[2.88, 3.14]	-0.22 [-0.35, -0.09]
External																					
Male	3.47	0.08	[3.31, 3.63]	3.17	0.08	[3.02, 3.32]	**-0.30 [-0.45, -0.15]**	3.32	0.09	[3.14, 3.49]	3.37	0.08	[3.21, 3.52]	0.05 [-0.10, 0.20]	3.36	0.09	[3.17, 3.54]	3.22	0.08	[3.07, 3.37]	-0.14 [-0.29, 0.02]
Female	3.56	0.06	[3.45, 3.68]	3.37	0.05	[3.27, 3.47]	**-0.20 [-0.30, -0.10]**	3.57	0.06	[3.45, 3.69]	3.28	0.05	[3.17, 3.38]	**-0.29 [-0.40, -0.19]**	3.44	0.06	[3.32, 3.57]	3.21	0.05	[3.11, 3.32]	**-0.23 [-0.34, -0.13]**
BMI (kg/m2)																					
Male	33.41	0.28	[32.86, 33.96]	32.58	0.26	[32.07, 33.09]	**-0.84 [-1.35, 0.33]**	33.74	0.32	[33.12, 34.36]	32.73	0.27	[32.20, 33.27]	**-1.00 [-1.54, -0.47]**	33.69	0.32	[33.05, 34.32]	32.25	0.27	[31.72, 32.78]	**-1.44 [-1.97, -0.91]**
Female	33.00	0.20	[32.61, 33.39]	32.83	0.18	[32.48, 33.18]	-0.17 [-0.52, 0.18]	32.88	0.21	[32.46, 33.29]	33.06	0.18	[32.69, 33.42]	0.18 [-0.18, 0.54]	32.63	0.22	[32.19, 33.06]	33.17	0.19	[32.80, 33.54]	0.54 [0.17, 0.91]
Step count/ day																					
Overall	6793.14	319.25	[6167.43, 7418.85]	6867.78	273.09	[6332.56, 7403.01]	74.64 [-460.58, 609.87]	6547.14	241.01	[6074.77, 7019.50]	6777.69	192.97	[6399.47, 7155.91]	230.56 [-147.67, 608.78]	6836.39	243.61	[6358.93, 7313.85]	7114.21	188.18	[6745.38, 7483.04]	277.82 [-91.01, 646.65]

[1] Estimates were reported separately for men and women if a significant group*time*gender interaction was detected.

Note. Bold text indicates significant between-group effects. Displayed are the results of the multilevel model analysis for each outcome (restrained eating, emotional eating, external eating, BMI, step count/day) adjusted for baseline value and assessment (3 months, 9 months, 15 months). Each model contained an interaction term for time*group and, in case the interaction was significant, an interaction for time*group*gender.

ADDITIONAL FILE 2

Differential Effects of the Individualized Gender-Sensitive mHealth Intervention I-GENDO on Eating Styles in Individuals with Overweight and Obesity – A Randomized Controlled Trial; Seiferth, C.; Färber, T.; Pape, M.; Schoemann, N.; Dieberger, A.; Schroeder, S.; Herpertz, S.; Wolstein, J.; Steins-Loeber, S.

Table A1 Model-estimated means, standard errors, and 95%CI for the self-reported outcomes at 3, 9 and 15 months, not adjusted for baseline value.

	3 months							9 months							15 months						
	Control			Intervention			Between-group difference [95% CI]	Control			Intervention			Between-group difference [95% CI]	Control			Intervention			Between group difference [95% CI)
	Mean	SE	95% CI	Mean	SE	95% CI		Mean	SE	95%CI	Mean	SE	95%CI		Mean	SE	95%CI	Mean	SE	95%CI	
Restrained																					
Overall	2.89	0.07	[2.76, 3.01]	3.10	0.06	[2.98, 3.22]	**0.20 [0.08, 0.32]**	2.91	0.07	[2.77, 3.05]	2.98	0.06	[2.86, 3.10]	**0.07 [-0.05, 0.19]**	2.83	0.07	[2.68, 2.97]	2.88	0.06	[2.76, 3.00]	**0.54 [-0.07, 0.18]**
Emotional																					
Male[1]	2.67	0.17	[2.34, 3.00]	2.52	0.15	[2.22, 2.82]	-0.16 [-0.46, 0.15]	2.46	0.18	[2.11, 2.81]	2.60	0.16	[2.29, 2.91]	0.14 [-0.17, 0.45]	2.56	0.18	[2.21, 2.91]	2.71	0.16	[2.41, 3.02]	0.15 [-0.16, 0.46]
Female	3.36	0.12	[3.13, 3.59]	3.17	0.11	[2.96, 3.38]	-0.19 [-0.40, 0.02]	3.55	0.12	[3.32, 3.79]	3.21	0.11	[2.99, 3.42]	**-0.35 [-0.56, -0.13]**	3.47	0.12	[3.22, 3.71]	3.19	0.11	[2.98, 3.41]	-0.28 [-0.49, -0.06]
External																					
Male[1]	3.32	0.13	[3.07, 3.58]	3.11	0.12	[2.87, 3.34]	**-0.21 [-0.45, 0.02]**	3.16	0.14	[2.89, 3.44]	3.30	0.12	[3.06, 3.54]	0.13 [-0.10, 0.37]	3.19	0.14	[2.92, 3.47]	3.16	0.12	[2.92, 3.39]	-0.03 [-0.27, 0.02]
Female	3.61	0.09	[3.43, 3.79]	3.39	0.08	[3.24, 3.56]	**-0.22 [-0.38, -0.05]**	3.61	0.09	[3.43, 3.79]	3.30	0.14	[3.14, 3.46]	**-0.31 [-0.48, -0.14]**	3.50	0.09	[3.31, 3.69]	3.25	0.09	[3.08, 3.42]	**-0.25 [-0.42, -0.09]**
BMI (kg/m2)																					
Male[1]	32.78	0.73	[31.34, 34.22]	32.44	0.65	[31.15, 33.74]	**-0.34 [-1.63, 0.95]**	33.04	0.75	[31.57, 34.52]	32.56	0.66	[31.26, 33.87]	**-0.48 [-1.79, -0.82]**	32.96	0.75	[31.49, 34.44]	32.08	0.66	[30.77, 33.38]	**-0.89 [-2.19, 0.42]**
Female	32.95	0.50	[31.96, 33.94]	33.28	0.46	[32.36, 34.19]	0.32 [-0.58, 1.24]	32.80	0.51	[31.80, 33.81]	33.50	0.46	[32.59, 34.42]	0.70 [-0.22, 1.62]	32.60	0.51	[31.59, 33.61]	33.61	0.46	[32.69, 34.53]	1.01 [0.09, 1.93]
Step count/ day																					
Overall	6868.89	403.82	[6077.41, 7660.36]	6559.34	355.04	[5863.46, 7255.21]	-309.55 [-1005.42, 386.32]	6717.74	333.62	[6063.85, 7371.63]	6613.26	284.84	[6054.99, 7171.54]	-104.47 [-662.75, 453.80]	7117.39	335.84	[6459.15, 7775.63]	6997.36	279.77	[6449.02, 7545.70]	-120.02 [-668.36, 428.31]

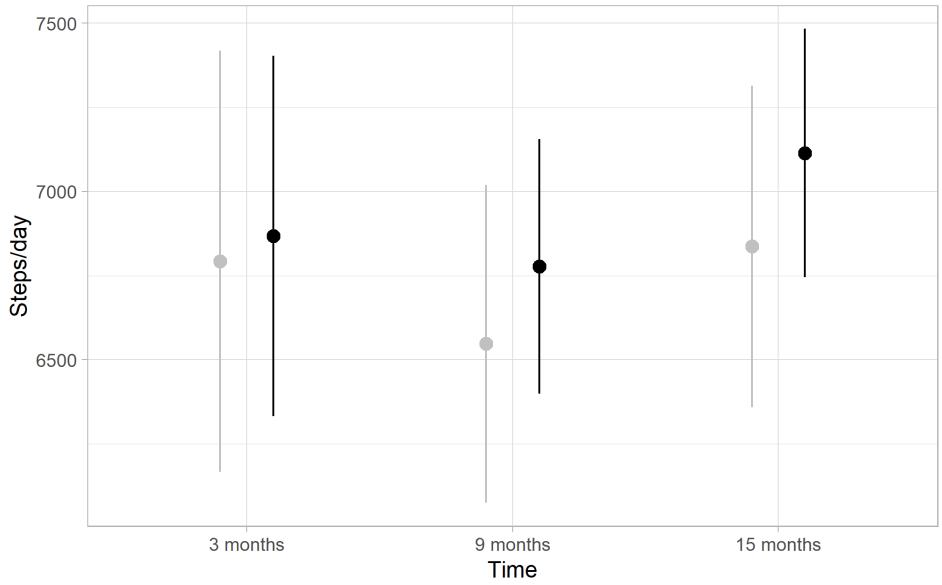
[1] Estimates were reported separately for men and women if a significant group*time*gender interaction was detected.

Note. Bold fond indicate significant between-group effects. Displayed are the results of the multilevel model analysis for each outcome (restrained eating, emotional eating, external eating, BMI, step count/day) and assessment (3 months, 9 months, 15 months). Each model contained an interaction term for time*group and, in case the interaction was significant, an interaction for time*group*gender.

ADDITIONAL FILE 3

Differential Effects of the Individualized Gender-Sensitive mHealth Intervention I-GENDO on Eating Styles in Individuals with Overweight and Obesity – A Randomized Controlled Trial; Seiferth, C.; Färber, T.; Pape, M.; Schoemann, N.; Dieberger, A.; Schroeder, S.; Herpertz, S.; Wolstein, J.; Steins-Loeber, S.

Figure A1. Intervention effect for the physical activity outcome at each assessment.



Legend. Between-group differences (black = intervention group, gray = control group) adjusted for baseline value for step count per day at each assessment.

Anhang C: Food Addiction and Its Relationship to Weight- and Addiction-Related Psychological Parameters in Individuals With Overweight and Obesity

Pape, M., Herpertz, S., Schroeder, S., Seiferth, C., Färber, T., Wolstein, J., & Steins-Loeber, S. (2021). Food addiction and its relationship to weight-and addiction-related psychological parameters in individuals with overweight and obesity. *Frontiers in Psychology*, *12*, 736454. https://doi.org/10.3389/fpsyg.2021.736454

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Food Addiction and Its Relationship to Weight- and Addiction-Related Psychological Parameters in Individuals With Overweight and Obesity

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Background and Aims: It is assumed that a relevant subgroup of individuals experiences an addiction-like eating behaviour (Food Addiction), characterized by an impaired control over eating behaviour, emotional eating and food craving. Individuals experiencing Food Addiction partially share common symptomatology with Binge-Eating-Disorder and Bulimia Nervosa. The aim of this study was to investigate the prevalence of Food Addiction, general psychopathology, and associations with weight- and addiction-related constructs in individuals with overweight and obesity, who did not suffer from Binge-Eating-Disorder or Bulimia Nervosa.

Methods: $N = 213$ (67.1% female; $M_{BMI} = 33.35\,kg/m^2$, $SD_{BMI} = 3.79\,kg/m^2$) participants who were included in a weight loss program (I-GENDO project) reported BMI and completed questionnaires before the start of the treatment. Food Addiction severity, depressive symptoms, alcohol use disorder, internet use disorder, psychological distress, impulsivity personality trait, impulsive and emotional eating behaviour, food related inhibitory control, weight bias internalization, and self-efficacy were assessed.

Results: The prevalence of Food Addiction was 15% with higher, although not statistically significant, prevalence in female (18.2%) compared to male (8.6%) participants. Food Addiction was associated with higher BMI at baseline assessment, low self-esteem, impulsive and emotional eating behaviour, weight bias internalization, and deficits in food-related inhibitory control. In addition, correlations were found between Food Addiction and severity of depressive symptoms, internet use disorder, and psychological distress.

Conclusion: A relevant subgroup of participants experiences Food Addiction even when controlling for Binge-Eating-Disorder and Bulimia Nervosa. Future studies are warranted that investigate whether Food Addiction affects treatment success.

Keywords: food addiction, obesity, overweight, eating disorders, eating behaviour, weight loss treatment

INTRODUCTION

In the last decades, the prevalence of overweight and obesity has increased dramatically worldwide, causing not only physical, but also mental health problems, including depression and anxiety disorders (Chu et al., 2019). Various weight loss programs (WLPs) have been developed mainly based on physical activity, diets, and change in eating habits (Jensen and Ryan, 2014). These *lifestyle interventions* often lack long-term effectiveness (Jeffery et al., 2000; Ross Middleton et al., 2012) due to an "obesogenic environment" (Swinburn et al., 1999) that promotes gaining weight, and is not conducive to weight loss within the home or workplace (hypercaloric diet, physical inactivity). Furthermore, relevant individual psychological aspects associated with eating behaviour are not sufficiently considered (Chalk, 2004).

A subgroup of individuals with overweight and obesity describes themselves as being "addicted" to food, characterized by an impaired control over their eating behaviour, emotional eating and food craving (Davis et al., 2013; Meule, 2015). Firstly, the addiction model of overeating was introduced by self-help groups and is even today controversially discussed in the scientific community (Naish et al., 2018; Hebebrand and Gearhardt, 2021). In 2009, the Yale Food Addiction Scale (YFAS), the first formal measure of *Food Addiction* (FA), was introduced. Originally based on the DSM-IV criteria for diagnosing substance use disorders (SUD) the YFAS was adapted to addictive overeating (Gearhardt et al., 2009). With the updated criteria for addictive disorders in the DSM-5, the YFAS 2.0 was developed in 2016 (Gearhardt et al., 2016). Until now, FA is not formally included as a distinct category in DSM-5 or ICD-11, but is based on criteria for addictive disorders as defined in these diagnostic manuals.

The concept of FA gains support from neurobiological findings, reporting food related brain activities, i.e., in the dopaminergic reward system, similar to those of drug intake (Gearhardt et al., 2011; Grosshans et al., 2012; Beitscher-Campbell et al., 2016; Novelle and Diéguez, 2018). Consistent with neurobiological similarities, individuals experiencing FA share specific behavioural deficits and personality traits with individuals suffering from SUDs, such as increased impulsivity (VanderBroek-Stice et al., 2017). Impulsivity is a multidimensional construct characterized by deficient inhibitory processes and low self-control. There are mainly three components of impulsivity to be distinguished: *impulsive personality trait*, *impulsive actions*, i.e., deficits in behavioural inhibition (action withdrawal, action cancellation), and *impulsive choices*, i.e., the tendency towards immediate rewards instead of long-term goals (delay discounting; Hofmann et al., 2009; Bari and Robbins, 2013; Mole et al., 2015). Individuals experiencing FA report a tendency to consume immediate disposable high-caloric food, as well as problems in resisting eating impulses (Meule, 2017; VanderBroek-Stice et al., 2017; Preuss et al., 2019). In general, individuals experiencing FA are characterized by high impulsivity traits (Mobbs et al., 2010; Churchill and Jessop, 2011; Murphy et al., 2014). Individuals with overweight and obesity experiencing weight stigmatization are likely to internalize negative stereotypes and to attribute them to their own weight (weight bias internalization, WBI; Puhl and Heuer, 2009). WBI is assumed to be linked to emotional eating and FA, resulting in maladaptive eating patterns (Baldofski et al., 2016). FA is associated with low self-esteem, high psychological distress, lower quality of life and depressive symptoms (Gearhardt et al., 2012; Burmeister et al., 2013; Minhas et al., 2021; Vidmar et al., 2021). From a psychobiological perspective, there is the assumption that similar processes in FA and other addiction disorders may be operating, which might explain the similarities and the high comorbidity of FA with substance-related disorders and behavioural addictions (Davis and Carter, 2009; García-García et al., 2014; Marmet et al., 2019).

In Germany, about 7.9% of the general population suffer from FA, with increasing prevalence rates in individuals with overweight (17.2%; Hauck et al., 2017). According to a meta-analysis of $N = 25$ studies, the prevalence of FA is higher in individuals with overweight and obesity (weighted mean prevalence, WMP: 25%), females (WMP: 12%) and individuals aged over 35 years (WMP: 22%; Pursey et al., 2014). To date, numerous heterogeneous results about the effect of FA on body weight and the influence on the success of WLPs have been published. In general, FA symptom severity is associated with higher BMI (Pursey et al., 2014). Some studies report higher study attrition and lower effectiveness of WLPs in individuals experiencing FA, while other studies did not find differences to individuals who are not experiencing FA (Burmeister et al., 2013; Clark and Saules, 2013; Meule et al., 2015; Fielding-Singh et al., 2019). Yet, the prevalence of FA in WLP samples is high (up to 34,5–38%; Meule et al., 2015; Vidmar et al., 2021). At least partially, some authors explain the relationship between FA and weight history as a result of comorbid mental disorders, particularly eating disorders (Eichen et al., 2013; Lent et al., 2014; Chao et al., 2019). Prevalence rates of FA in adults with Binge-Eating-Disorder (BED) range from 40 to 50%, while in individuals with Bulimia Nervosa (BN) the prevalence rises over 80% (Gearhardt et al., 2014; De Vries and Meule, 2016). Additionally, the prevalence of eating disorders, i.e., BED (up to 30%), are also higher in participants undergoing weight loss interventions (Herpertz et al., 2006; Blaine and Rodman, 2007; Davis, 2015).

The high comorbidity may be due to the fact that BED, BN and FA share common mechanisms such as binge-eating and reward dysfunction (Burrows et al., 2018). Especially the emotional component (e.g., fear of not being able to stop and guilt surrounding binge eating episodes) of BED seems to be associated with increased FA severity (Burrows et al., 2017). Thus, FA overlaps with BN and BED (Gearhardt et al., 2013; Meule et al., 2014; Meule, 2019b). Yet, there are also dissimilarities, which distinguish FA from BED and BN (Schulte et al., 2020). When conceptualizing FA as a specific form of SUDs, highly palatable and processed foods act as drugs. Yet, individuals experiencing FA need not necessarily binge these drugs, but could also graze them throughout the day, similar to other SUDs. Additionally, some studies report specific food-related withdrawal and tolerance symptoms (Avena et al., 2008; Burger and Stice, 2012).

Taken together, despite its similarities to other SUDs FA is currently not an officially recognized diagnosis. One contentious issue in the recent debate about the need of an FA diagnosis is the mentioned overlap of FA symptoms with those of other eating disorders (Gearhardt and Hebebrand, 2021; Hebebrand and Gearhardt, 2021). In order to contribute to this question, we analysed FA in a sample of individuals with overweight and obesity participating at a 12-week long WLP, who did not suffer from BED or BN.

The aims of our study were:

1. To analyse the prevalence of FA in a sample of individuals with overweight and obesity seeking treatment, who did not suffer from BED or BN.
2. To analyse relationships between FA severity, eating behaviours, general psychopathology and weight- and addiction-related factors, such as impulsivity, food related inhibitory control, self-efficacy and weight bias internalization.
3. To further characterize the subgroup of FA in contrast to non-food-addicted (NFA) participants.

MATERIALS AND METHODS

Procedure

The dataset of this manuscript is retrieved from the I-GENDO project (*Gender-sensitive Enhancement of Common Weight Loss Strategies for Overweight and Obesity*, ClinicalTrials.gov Identifier: NCT04080193) a multicentre randomized controlled trial to assess the effectivity of a gender sensitive individualized smartphone-based intervention to reduce weight. Interested individuals were recruited from August 2019 until August 2020 *via* newspaper articles, radio features and oral presentations at rehab centres. At the baseline assessment the participants completed questionnaires and reported their current weight (kg) and height (m), of which the individual BMI (kg/m^2) was calculated.

Participants

Table 1 displays the eligibility criteria of the I-GENDO project. Following the guidelines of the German Society for General and Visceral Surgery (DGAV) and the German Association for the Study of Obesity (DAG) individuals with obesity class III (BMI > 39.9) suffer from a complex multifactorial framework of psychological, social and physical problems and are therefore recommended to undergo a bariatric surgery. In order to avoid potentially confounding effects, we excluded individuals with obesity class III from participation, but provided further support. During the recruitment process we screened for major depression with the PHQ-9 (Löwe et al., 2002). Interested subjects who scored above the cut-off for major depression (≥ 20) were excluded from participation (Kroenke et al., 2001). Furthermore, if suicidal ideation was reported, people were contacted and subsequently diagnosed *via* telephone with a structured interview to clarify suicidal intentions by experienced psychologists. When suicidal ideation could not be convincingly negated by clinical judgement, subjects were referred further and excluded from this study. In prior studies heavy drinking was consistently associated with gaining weight, which we expected could influence the effectiveness of the WLP (Traversy and Chaput, 2015). Using the Alcohol Use Disorders Identification Test (AUDIT, Saunders et al., 1993) subjects were excluded when the sum score of the AUDIT was 15 or more, suggesting hazardous alcohol consumption (Conigrave et al., 1995). In case of suspected eating disorders, as assessed by the Munich ED-Quest (Fichter et al., 2015), subjects were contacted and subsequently diagnosed by experienced psychologists using the German version of the Eating Disorder Examination (EDE), a clinical interview for the assessment of eating disorder specific psychopathology (Hilbert and Tuschen-Caffier, 2016). Individuals who were diagnosed with BN or BED were excluded from participation.

The final sample consisted of $N = 213$ (67.1% female) individuals with obesity or overweight ($M_{BMI} = 33.35\,kg/m^2$, $SD_{BMI} = 3.79\,kg/m^2$). Age ranged between 19 and 71 years ($M_{age} = 46.45$ years, $SD_{age} = 12.13$ years).

Measures

Food Addiction (YFAS 2.0)

Addiction-like eating (during the past 12 months) was measured using the YFAS Scale 2.0 (Gearhardt et al., 2016). The YFAS 2.0 consists of 35 items, which are scored on an 8-point scale ranging from *never* to *every day*. Based on the 11 diagnostic criteria for SUDs in the DSM-5 (e.g., craving, tolerance or withdrawal) a symptom score ranging between 0 and 11 is calculated, reflecting the FA symptom severity. Additionally, clinically significant impairments or distress due to the eating

TABLE 1 | Eligibility criteria of the I-GENDO project.

Inclusion Criteria	Exclusion criteria
Legal age (≥18 years).	
Obesity class I or II with subjectively experienced weight-related impairment and a current intention to lose weight.	Obesity class III (i.e., BMI > 39.9 kg/m^2).
Overweight (i.e., BMI between 25 and 29.9 kg/m^2) with weight-related health problems and/or visceral adipose tissue and/or high psychosocial weight-related distress with a current intention to lose weight.	Current (or within the last 12 months) involvement in a structured weight loss intervention.
	Insulin-dependent type 1 diabetes.
	Previous or intended bariatric surgery.
	Current psychotherapeutic treatment of weight-related health problems.
	Weight-enhancing drugs.
	Drugs which promote weight-loss (e.g., anti-obesity drugs).
	Weight-enhancing health problems which are not yet treated.
	Cancerous disease within the last 5 years.
	Current substance-use disorders, major depression, psychosis, suicidal tendency or pregnancy.
	Severe cognitive impairments.
	Insufficient knowledge of the German language.
	Binge-Eating-Disorder or Bulimia nervosa.

behaviour are assessed. Food addiction (FA) is diagnosed when two or more symptoms are met (=symptom score ≥ 2) together with clinically significant impairments or distress due to the eating behaviour. The German version of the YFAS 2.0 was used (Meule et al., 2017) and showed excellent internal consistency, $\alpha = 0.91$, in the present sample.

Eating Disorders (Munich ED-Quest)

The Munich Eating and Feeding Disorder Questionnaire (Munich ED-Quest, Fichter et al., 2015) was used to screen for BN and BED. The whole questionnaire consists of 65 items assessing core symptoms of BN, BED, Anorexia Nervosa, Purging Disorder and Night Eating Syndrome within the last 3 months. In our study, only 32 items were assessed screening for core symptoms of BED and BN based on the DSM-5 criterions (e.g., binge eating episodes, inappropriate compensatory behaviour, significant distress caused by binge eating episodes). Participants were instructed to indicate the severity of their symptomatology by either rating the corresponding items on a 5-Point Likert scale ranging from 0 to 4, or by estimating average frequencies (e.g., of binge eating episodes). Reliability of Munich ED-Quest (internal consistency of $\alpha = 0.94$) and validity are determined in a clinical sample of eating disorder patients in Germany (Fichter et al., 2015).

Depression (PHQ-9)

Depressive symptoms in the last 2 weeks were measured using the Patients-Health-Questionnaire-9 (PHQ-9, Löwe et al., 2002). The screening instrument consists of nine items, corresponding to the DSM-IV major depression criteria, which are scored on a 4-point scale ranging from *not at all* (0) to *nearly every day* (3). The symptom score ranges between 0 and 27, with scores above 20 indicating major depression (Kroenke et al., 2001).

Alcohol Use Disorder (AUDIT)

The Alcohol Use Disorders Identification Test (AUDIT) was developed by the World Health Organization (WHO) to identify risky or harmful alcohol consumption, and alcohol use disorder (AUD; Saunders et al., 1993). The self-report questionnaire consists of 10 items. Each item is scored between 0 and 4. The sum score ranges between 0 and 40 points, with scores above the cut-off of 15 reflecting hazardous alcohol consumption (Conigrave et al., 1995). We used the German version of the AUDIT showing good psychometric properties in a German general practice population sample (Dybek et al., 2006). The internal consistency was adequate, $\alpha = 0.68$, in the present sample.

Internet Use Disorder (AICA-S)

The Assessment of Internet and Computer Game Addiction Scale (AICA-S, Wölfling et al., 2016) was used to measure problematic and pathological internet use. The AICA-S is a self-report questionnaire, consisting of 17 items, of which 14 are relevant for the clinical classification of pathological internet use based on the DSM-5-criteria for SUD. Scores of 13 or greater indicate internet use disorder (IUD). Reliability (internal consistency of $\alpha = 0.89$) and validity of the AICA-S are determined in the general population (Müller et al., 2014).

Psychological Distress (BSI-18)

The German short version of the Brief Symptom Inventory (BSI-18, Derogatis and Fitzpatrick, 2004) was used to assess psychological distress. The self-report questionnaire consists of 18 items which are rated on a five-point Likert scale ranging from *not at all* (0) to *always* (4). The total score indicates general distress (global severity index, GSI) and ranges between 0 and 72 points. The German translation of the scale showed good psychometric qualities in a sample of undergraduate students, non-clinical subjects and psychosomatic outpatients (Spitzer et al., 2011). The BSI-18 showed an excellent internal consistency, $\alpha = 0.85$, in the present sample.

Impulsivity (BIS-15)

To assess impulsivity as a personality trait, the short version of the German Barratt Impulsiveness Scale (BIS-15, Meule et al., 2011) was used. The self-report questionnaire consists of 15 items, which are scored on a four-point scale from *seldom/never* (1) to *almost always/always* (4). The overall sum score of impulsivity ranges between 15 and 60, with higher scores indicating higher degrees of impulsivity. In our study, the overall impulsivity trait was analysed. The internal consistency was good, $\alpha = 0.80$, in the present sample.

Impulsive Eating Behaviour (FEV)

The subscale *interference* of the Eating Behaviour Questionnaire (FEV, Pudel and Westenhöfer, 1989) was used to assess impulsive eating behaviour. The FEV_In consists of 16 items, each answered with either *true* (1) or *not true* (2). Three items are inverted (8, 10, and 12). The internal consistency was adequate, $\alpha = 0.71$, in the present sample.

Food Related Inhibitory Control (FRIS)

The Food Related Inhibitory Control Scale (FRIS, C. Seiferth and colleagues, not yet published) is a newly developed questionnaire, currently revised and validated, which consists of 40 items, each of it answered on a scale from *strongly disagree* (0) to *strongly agree* (5). The total score ranges between 0 and 200, with higher scores indicating increased food related inhibitory control. Preliminary validation proposes a four-factor solution with the subscales Action Withdrawal (AW, e.g., item: "I eat unconsciously between the meals," Cronbach's $\alpha = 0.82$), Action Cancellation (AC, e.g., item: "Once I started eating, I cannot stop anymore.," Cronbach's $\alpha = 0.86$), Reward Sensitivity (RS, e.g., item: "I reward myself with eating," Cronbach's $\alpha = 0.69$) and Delay Discounting (e.g., item: "If I get hungry, I chose rapidly available food," Cronbach's $\alpha = 0.72$).

Emotional Eating Behaviour (DEBQ)

The subscale *emotional eating* of the German translation of the Dutch Eating Behaviour Questionnaire (DEBQ, Van Strien et al., 1986) was used to measure emotional eating behaviour. The original self-report questionnaire consists of 30 items. The emotional eating subscale (DEBQ_EE) consists of 10 items, all answered on a five-point Likert scale ranging from *never* (1) to *very often* (5). The subscale score ranges between 10

and 50 points. Good psychometric properties of the German version of the scale have been demonstrated by Nagl and colleagues (Nagl et al., 2016). The internal consistency was excellent, $\alpha = 0.92$, in the present sample.

Weight Bias Internalization (WBI)

The German version of the Weight Bias Internalization Scale (WBIS, Hilbert et al., 2014) was used to measure internalized negative stereotypes and prejudice regarding overweight. The WBIS consists of 11 items which are rated on a seven-point scale ranging from *strongly disagree* (1) to *strongly agree* (7). The total score ranges between 11 and 77. The German version showed good psychometric properties (Hilbert et al., 2014). The internal consistency was good, $\alpha = 0.86$, in the present sample.

Self-Efficacy (SWE)

To measure self-efficacy, the General Self-Efficacy Scale (SWE, Jerusalem and Schwarzer, 2003) was used. The self-report questionnaire consists of 10 items, each of it answered on a four-point scale ranging from *not at all true* (1) to *exactly true* (4), yielding a total score between 10 and 40 points. The SWE showed good psychometric properties in a representative German sample (Hinz et al., 2006). The internal consistency was good, $\alpha = 0.88$, in the present sample.

Statistical Analysis

All analyses were conducted with *IBM SPSS statistics for windows* (Version 26.0, Armonk, NY: IBM Corp.) and *Microsoft Excel* (Version 16.0, Microsoft Corporation). Descriptive analyses were conducted using percentages and frequencies for categorical variables, as well as means and standard deviations for continuous variables. *Chi-square* distributions that compared categorical variables between groups (FA vs. NFA) were implemented as well as Bonferroni-adjusted independent *t*-tests to compare metrically scaled variables. Associations between metrically scaled variables were analysed using *Pearson correlations*.

Ethics

The study was carried out in accordance with the Declaration of Helsinki. The Institutional Review Board of the Ruhr-University Bochum approved the study (Nr. 18-6415). All subjects were informed about the study and all provided written informed consent.

RESULTS

Prevalence of Food Addiction

The prevalence of *Food Addiction* was 15% ($N = 32$), with higher, although not statistically significant, prevalence rates in female (18.2%, $N = 26$) compared to male (8.6%, $N = 6$) participants.

Table 2 gives an overview about sociodemographic factors both of the total sample and the subsamples of individuals experiencing food addiction (FA) or not experiencing FA (NFA). No differences between the subsamples (FA vs. NFA) regarding gender, age, BMI, marital status and education could be found.

Food Addiction, Psychopathology and Weight- and Addiction-Related Constructs

Correlation analyses revealed a significant positive association ($r = 0.17$, $p = 0.014$) between symptom severity of FA and BMI at baseline assessment (**Table 3**). With regard to psychopathology, FA symptom severity was positively correlated to severity of depressive symptoms ($r = 0.33$, $p < 0.001$), severity of IUD ($r = 0.18$, $p = 0.011$) and psychological distress ($r = 0.35$, $p < 0.001$). An impulsive ($r = 0.48$, $p < 0.001$) and emotional eating behaviour ($r = 0.36$, $p < 0.001$) as well as WBI ($r = 0.44$, $p < 0.001$) was positively associated with FA. There were negative correlations between FA symptom severity and the subscales action withdrawal ($r = -49$, $p < 0.001$), action cancellation ($r = -0.41$, $p < 0.001$), reward sensitivity ($r = -0.46$, $p < 0.001$) and delay discounting ($r = -0.27$, $p < 0.001$) of the FRIS. A decrease in self-efficacy was also associated with FA symptom severity ($r = -0.21$, $p = 0.002$).

Table 4 illustrates results from independent t-Tests between the subsamples (FA vs. NFA) on psychosocial measurements and psychopathology. FA participants showed significantly higher FA symptom severity (YFAS 2.0) than NFA participants did. Additionally, the GSI (BSI-15) was higher for FA compared to NFA participants, indicating higher psychological distress. Comparisons of psychosocial measurements associated with eating behaviour indicated that FA participants suffer from a more impulsive (FEV_In) and emotional eating behaviour (DEBQ_EE), as well as weight bias internalization (WBIS). Moreover, FA participants scored less on three of four FRIS subscales (AW, AC and RS), indicating impairments in behavioural inhibitory control and increased reward sensitivity. The groups did not differ on the subscale DD, reflecting impulsive choices.

TABLE 2 | Sociodemographic factors (FA vs. NFA).

	Overall ($N = 213$)	FA ($N = 32$)	NFA ($N = 181$)	FA vs. NFA
Sex	$n_f = 143$, 67.1%	$n_f = 26$, 81.3%	$n_f = 117$, 64.6%	$\chi^2(1) = 3.40$, p = ns
	$n_m = 70$, 32.9%	$n_m = 6$, 18.8%	$n_m = 64$, 35.4%	
Age (years)	M = 46.45, SD = 12.13	M = 48.28, SD = 12.14	M = 46.12, SD = 12.13	$t(211) = 0.93$, p = ns
BMI (kg/m^2)	M = 33.35, SD = 3.79	M = 34.48, SD = 3.27	M = 33.15, SD = 3.85	$t(211) = 1.84$, p = ns
Marital Status*	$n_{yes} = 170$, 79.8%	$n_{yes} = 26$, 81.3%	$n_{yes} = 144$, 79.6%	$\chi^2(1) = 0.05$, p = ns
Education**	$n_{uni} = 61$, 27.9%	$n_{uni} = 8$, 25.0%	$n_{uni} = 53$, 29.3%	$\chi^2(1) = 0.24$ p = ns

*FA, participants experiencing Food Addiction; NFA, participants not experiencing Food Addiction; $n_{f/m}$, number of female/male participants; n_{yes}, number of participants living in a relationship; n_{uni}, number of participants who graduated university. *Marital status: currently living in a relationship yes/no. **Education: highest educational degree (in this case: university). n.s. = not significant*

TABLE 3 | Pearson correlations among psychological test scores (*N* = 213).

S. No.		1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.
1.	YFAS 2.0															
2.	Age (years)	0.036														
3.	BMI (kg/m^2)	0.168*	−0.104													
4.	PHQ-9	0.334**	−0.225**	−0.046												
5.	AUDIT	−0.086	−0.030	−0.206**	0.037											
6.	AICA-S	0.175*	−0.237**	0.027	0.267**	−0.077										
7.	BSI-15	0.350**	−0.078	−0.049	0.563**	0.029	0.247**									
8.	BIS-18	0.056	0.035	0.093	0.128	0.005	0.168*	0.172*								
9.	FEV_In	0.478**	−0.158*	0.080	0.296**	−0.027	0.179**	0.352**	0.054							
10.	DEBQ_EE	0.356**	−0.135*	0.113	0.297**	−0.082	0.127	0.377**	−0.006	0.682**						
11.	WBIS	0.444**	−0.275**	0.268**	0.411**	−0.153*	0.236**	0.423**	0.121	0.460**	0.496**					
12.	SWE	−0.212**	−0.023	0.047	−0.323**	0.044	−0.089	−0.441**	−0.104	−0.273**	−0.265**	−0.311**				
13.	FRIS_AW	−0.487**	0.218**	−0.126	−0.212**	0.027	−0.282**	−0.201**	−0.037	−0.612**	−0.475**	−0.360**	0.137*			
14.	FRIS_AC	−0.407**	0.222**	−0.067	−0.211**	−0.108	−0.230**	−0.205**	−0.035	−0.620**	−0.404**	−0.338**	0.179**	0.708**		
15.	FRIS_RS	−0.461**	0.178**	−0.102	−0.205**	0.076	−0.195**	−0.213**	0.075	−0.636**	−0.620**	−0.416**	0.155*	0.626**	0.592**	
16.	FRIS_DD	−0.274**	0.110	−0.077	−0.237**	0.168*	−0.191**	−0.161*	−0.005	−0.341**	−0.341**	−0.282**	0.150*	0.389**	0.338**	0.447**

*YFAS, Yale Food Addiction Scale; PHQ-9, Patients-Health-Questionnaire-9 (depression); AUDIT, Alcohol Use Disorders Identification Test; AICA-S, Assessment of Internet and Computer Game Addiction Scale; BSI-15, Brief Symptom Inventory (Psychological Distress); BIS-18, Barratt Impulsiveness Scale (Impulsivity Personality Trait); FEV_In, Eating Behaviour Questionnaire (Subscale: Interference); DEBQ_EE, Dutch Eating Behaviour Questionnaire (subscale: Emotional Eating); WBIS, Weight Bias Internalization Scale; SWE, General Self-Efficacy Scale; FRIS, Food Related Inhibitory Control Scale (Subscales: AW, Action Withdrawal; AC, Action Cancellation; RS, Reward Sensitivity; DD, Delay Discounting). *Correlation is significant at the 0.05 level (2-tailed); **Correlation is significant at the 0.01 level (2-tailed).*

DISCUSSION

The main aim of the present study was to assess the prevalence of FA in a treatment-seeking sample of individuals with overweight or obesity and without comorbid BN or BED as previous studies did not control for these comorbid disorders. The prevalence of FA in our sample was 15%, with higher, although not statistically significant, rates in female (18.2%) compared to male participants (8.6%) as expected (Pursey et al., 2014). Notably, the higher prevalence rates in female participants might also be explained by a general tendency of women to over-report health problems compared to men (Boerma et al., 2016). Our findings fit the assumption that the prevalence of FA is higher in individuals with overweight and obesity (17.2%) compared to the general population (7.9%; Pursey et al., 2014; Hauck et al., 2017). Previous studies analysing FA in WLP samples, in which participants suffering from BED and BN were not excluded from participation, reported prevalence rates ranging between 15 and 38% (Eichen et al., 2013; Meule et al., 2015). The lower prevalence rate in our study might therefore be due to the fact, that individuals suffering from BN or BED were excluded from participation. Still, since 15% of our sample experienced FA, we thus conclude that, even when adjusting for comorbid eating disorders, a relevant subgroup of WLP participants experiences an addiction-like eating behaviour.

FA severity was associated with increased BMI, which is in line with findings of previous studies (Pedram et al., 2013; Gearhardt et al., 2014). A variety of studies reports associations between FA and SUDs (Davis and Carter, 2009; García-García et al., 2014; Tinghino et al., 2020). In our study, AUD severity was not associated with FA. This might be because hazardous alcohol consumption was an exclusion criterion for participation, but the missing correlation could also be masked by the inverse relationship between AUD and BMI. However, in line with previous studies, FA was associated with severity of depressive symptoms and psychological distress (Gearhardt et al., 2012; Burmeister et al., 2013). Although participants meeting the diagnostic criteria for major depression and AUD were excluded from participation, our results underline the strong relationship between FA symptomatology and mood disorders, and enlighten the high level of distress in individuals experiencing FA, which together might contribute to weight gain (Bourdier et al., 2018). FA was linked to IUD severity. IUD is a behavioural addiction characterized by excessive internet usage and an impaired control over usage behaviour (Young, 1996). Excessive internet usage is associated with unhealthy eating and sedentary behaviour and might subsequently aggravate FA symptomatology and contribute to weight gain (Vandelanotte et al., 2009; Yildirim et al., 2018).

Moreover, FA was linked to emotional eating and WBI and both were significantly higher in FA compared to NFA participants. There seems to be a shift from positive reinforcement to negative reinforcement in individuals experiencing FA regarding the consumption of palatable food (Parylak et al., 2011). Given that palatable food can be both rewarding and stress reducing, food deprivation may lead to

TABLE 4 | Psychopathology and weight- and addiction-related constructs (FA vs. NFA).

	Total ($N = 213$)		FA ($N = 32$)		NFA ($N = 181$)					FA vs. NFA
	M	SD	M	SD	M	SD				
YFAS 2.0	2.46	2.57	5.81	2.69	1.86	2.04	t(211) = 7.91	$p < 0.001$	d = 1.84	FA > NFA
PHQ-9	6.17	3.96	7.97	4.20	5.86	3.84	t(211) = 2.83	p = n.s.		
AUDIT	4.23	3.20	3.59	3.43	4.34	3.16	t(211) = 1.21	p = n.s.		
AICA-S	4.46	2.96	5.00	4.14	4.37	2.70	t(211) = 0.83	p = n.s.		
BSI-18	8.44	7.01	12.81	8.92	7.66	6.34	t(211) = 3.13	$p = 0.042$	d = 0.76	FA > NFA
BIS-15	30.85	5.96	30.50	6.38	30.91	5.89	t(211) = 0.36	p = n.s.		
FEV_In	9.69	3.24	11.31	2.95	9.41	3.22	t(211) = 3.12	$p = 0.028$	d = 0.60	FA > NFA
DEBQ_EE	3.06	1.02	3.70	0.85	2.94	1.01	t(211) = 4.01	$p < 0.001$	d = 0.71	FA > NFA
WBIS	44.08	13.31	54.84	11.41	42.17	12.74	t(211) = 5.27	$p < 0.001$	d = 1.01	FA > NFA
SWE	28.71	4.30	28.72	4.93	28.71	4.19	t(211) = 0.007	p = n.s.		
FRIS_AW	30.28	10.58	24.34	9.11	31.33	10.49	t(211) = 3.54	$p < 0.001$	d = 0.68	FA < NFA
FRIS_AC	29.09	9.97	24.22	11.29	29.96	9.49	t(211) = 3.06	$p = 0.042$	d = 0.59	FA < NFA
FRIS_RS	11.72	4.98	8.81	5.36	12.24	4.74	t(211) = 3.69	$p < 0.001$	d = 0.71	FA < NFA
FRIS_DD	12.38	3.90	11.03	3.88	12.62	3.87	t(211) = 2.14	p = n.s.		

Bonferroni-adjusted p values, effect size Cohen's d. n.s = not significant

withdrawal (i.e., stress enhancement) and a subsequent shift from gratification to compulsive eating. In line with previous studies, self-efficacy was negatively correlated to FA symptom severity in our sample (Burmeister et al., 2013; Cassin et al., 2019). Low self-efficacy and high WBI are linked to lower physical activity and WBI predicts reduced odds of achieving weight-loss in individuals with overweight and obesity (Hübner et al., 2015; Pearl et al., 2019). Therefore, the reported associations between FA, WBI and self-efficacy fits prior observations that individuals experiencing FA suffer from weight cycling (Gearhardt et al., 2014). It is assumed that the relationship between WBI and FA is moderated by emotional dysregulation, which should be further investigated (Baldofski et al., 2016). Future studies might also consider assessing weight control or eating self-efficacy instead of global self-efficacy (Linde et al., 2004; Cassin et al., 2019).

FA was associated with an impulsive eating behaviour and deficits in food-related inhibitory control. FA participants significantly differed from NFA participants in food-related impulsive actions (action withdrawal and cancelation), as well as reward sensitivity. This indicates that individuals experiencing FA have more problems in resisting impulses towards disposable and rewarding food and might therefore need specific training elements to enhance weight loss (Meule, 2019a). Delay discounting was associated with FA symptom severity, but the subgroup of FA participants did not significantly differ from NFA participants on this subscale. This might be due to the fact that delay discounting is generally increased in individuals with obesity (Mole et al., 2015). Interestingly, FA was not associated with the impulsivity personality trait. This is in contrast to prior studies indicating that FA, as well as other SUDs and EDs are associated with higher impulsivity traits (Mobbs et al., 2010; Churchill and Jessop, 2011; Murphy et al., 2014; VanderBroek-Stice et al., 2017). Since BN, BES and AUD were exclusion criteria in our study, it might be possible, that overlapping symptoms with this disorders confounded prior results. Based on our results, we hypothesize that not a global disposition towards impulsive behaviour, but rather a learning process that food is rewarding and disposable, may contribute to the impulsive eating behaviour in FA participants. In our study, impulsivity personality trait, impulsive eating behaviour and food-related inhibitory control were measured using self-reporting questionnaires. Since self-reported and behavioural results regarding disinhibition of eating behaviour in individuals with obesity can differ, the results of our study should be further analysed using behavioural tasks (Loeber et al., 2012). Furthermore, potential moderating factors like restrained eating or current mood should be considered (Loeber et al., 2018).

A particular strength of our study is that we analysed FA in a sample of individuals with overweight and obesity who did not suffer from eating disorders, which was verified by questionnaire and structured interview (*two stage design*). However, when interpreting the findings of the present study a few limitations should be acknowledged. Individuals with obesity class III ($BMI > 39.9\,kg/m^2$) were excluded from participation due to the study design of the WLP. It can be assumed that the prevalence of FA would have been higher when including these participants, since FA is reported to be increased in individuals experiencing extreme obesity (ca. 30%; Hauck et al., 2017). In addition, since AUD and major depression were exclusion criteria, the reported associations between FA, AUD severity and severity of depressive symptoms might be confounded. Since the risk for FA increases in polyabusers, the exclusion of individuals suffering from hazardous alcohol consumption might subsequently cause a lower prevalence of FA in our study (Tinghino et al., 2020). Finally, a broad test battery, i.e., with regard to different components of impulsivity and impulsive eating behaviour, was used. Still, our conclusions are based on results from self-reporting questionnaires and different results may be observed when using behavioural measurements as for example reported by Loeber et al. (2018). In addition, typical pre-test self-report biases are known, which might have further influenced our results (Aiken and West, 1990). Yet, despite its limitations, the YFAS is currently the "state-of-the-art" assessment of FA (Schulte et al., 2020). With a view to a

potential inclusion of FA in the diagnostic catalogues, it would make sense to develop and use objective diagnostic assessment tools, like structured interviews (Gearhardt and Hebebrand, 2021; Hebebrand and Gearhardt, 2021). The interpretation of our results is aggravated due to our cross-sectional study design, i.e., with regard to causal analyses. It would subsequently be meaningful to verify the results in longitudinal studies, i.e., with regard to long-term weight management in individuals experiencing FA.

Summing up, our results support the view that, even when adjusting for BN and BED, a relevant subgroup of individuals with overweight and obesity experiences an addiction-like eating behaviour. This subgroup differs from non-addictive eaters on several weight- and addiction-related factors, like emotional eating, WBI, and impulsivity. Moreover, individuals experiencing FA suffer from depressive symptoms, addictive disorders and psychological distress. In sum, these impairments may contribute to weight gain. If so, our results underline that the lack of an officially approved FA diagnosis might currently cause an insufficient clinical care for individuals experiencing an addiction-like eating behaviour. It might therefore be reasonable to investigate the effect of FA on weight loss when adjusting for eating disorders and to further implicate addiction-specific therapeutic elements in WLPs to enhance weight loss and prevent weight regain in this subgroup.

DATA AVAILABILITY STATEMENT

The datasets presented in this article are not readily available because data will be made available only on reasonable request. Requests to access the datasets should be directed to magdalena.pape@rub.de.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by The Institutional Review Board of the Ruhr-University Bochum (Nr. 18-6415). The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

MP: conceptualisation, acquisition of data, formal analysis, interpretation of data, and writing – original draft. SH: conceptualisation, writing- original draft, and study supervision. SS and CS: study design, acquisition of data, and review and editing. TF: acquisition of data and review and editing. JW: study design, study supervision, and review and editing. SS-L: study design and conceptualisation, study supervision, and review and editing. All authors contributed to the article and approved the submitted version.

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