HAROKOPIO UNIVERSITY

SCHOOL OF HEALTH SCIENCE AND EDUCATION

DEPARTMENT OF NUTRITION AND DIETETICS

POSTGRADUATE PROGRAM IN APPLIED NUTRITION AND DIETETICS

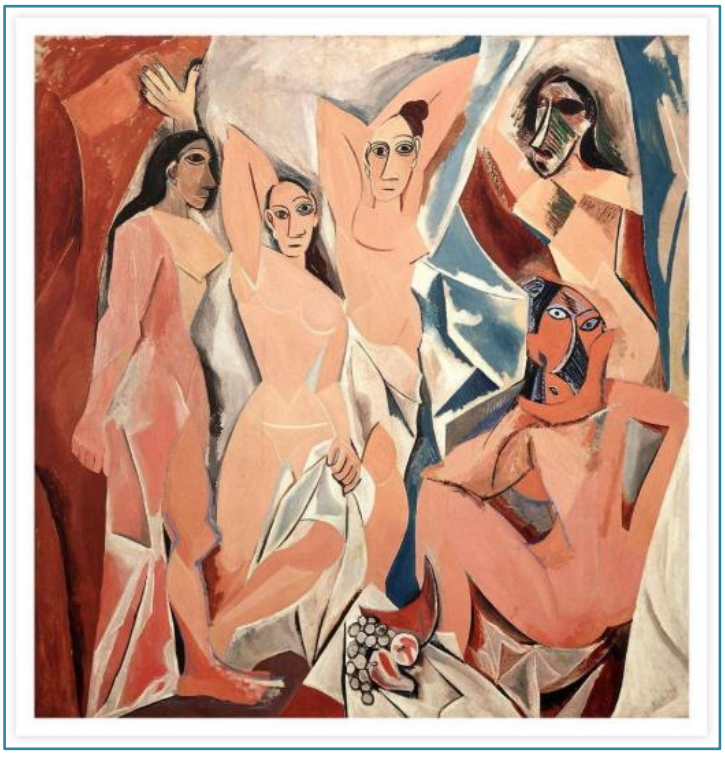
DISCIPLINE: CLINICAL NUTRITION

Title:

“Parents' perceptions of their weight and their children’s weight compared to the actual body weight status in families at high risk for type 2 diabetes in Europe.”

Master Thesis

Postgraduate student’s name: Nikolakea Eirini



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3-membered Examining Committee:

Supervisor: Ioannis Manios
Professor in Nutrition Education & Assessment,
Department of Nutrition and Dietetics,
HAROKOPIO UNIVERSITY

Mary Yiannakoulia
Associate Professor in Nutrition and Eating Behavior,
Department of Nutrition and Dietetics,
HAROKOPIO UNIVERSITY

Labros Sidossis
Professor in Nutrition – Dietetics,
Department of Nutrition and Dietetics,
HAROKOPIO UNIVERSITY

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Contents

1. Abstract

1.1 Table of abbreviations

Abbreviation	Definition
DM	Diabetes Mellitus
T1DM	Type 1 Diabetes Mellitus
T2DM	Type 2 Diabetes Mellitus
GDM	Gestational Diabetes Mellitus
WHO	World Health Organization
CVD	Cardiovascular disease
UW	Underweight
NW	Normal weight
OW	Overweight
OB	Obese
NEFA	Non-esterified fatty acids
BMI	Body Mass Index
HAPA	Health Action Process Approach
FINDRISK	Finnish Diabetes Risk Score
AF	All – families
HRF	High – risk families
OR	Odds ratio
CI	Confidence interval

1.2 Key words

Perception of weight status, weight underestimation, weight overestimation, parental perception

1.3 Abstract in Greek

Εισαγωγή: Παγκοσμίως περίπου μισό δισεκατομμύριο άνθρωποι ζουν με διαβήτη. Ο σακχαρώδης διαβήτης τύπου 2 (ΣΔτ2) είναι μια χρόνια νόσος, αποτέλεσμα της πολυσύνθετης αλληλεπίδρασης περιβαλλοντικών, γενετικών, επιγενετικών και παραγόντων του τρόπου ζωής. Ένας από τους κυριότερους παράγοντες κινδύνου είναι η παχυσαρκία. Καθώς η παχυσαρκία είναι μια τροποποιήσιμη κατάσταση, πλήθος προγραμμάτων πρόληψης έχουν επικεντρωθεί στην αντιμετώπιση της. Ως εκ τούτου, το ερώτημα που προκύπτει είναι γιατί πολλά από τα προαναφερόμενα προγράμματα δεν έχουν πετύχει τον στόχο τους. Ερευνητικά δεδομένα σε υγιή πληθυσμό προτείνουν ότι τα αυξανόμενα ποσοστά παχυσαρκίας τείνουν να διαστρεβλώσουν την έννοια του υγιούς σωματικού βάρους, με αποτέλεσμα ένα μεγάλο ποσοστό ενηλίκων να αντιλαμβάνεται λανθασμένα τη δική τους κατάσταση βάρους και του παιδιού τους. Συνεπώς, η εσφαλμένη αντίληψη βάρους αποτελεί συχνά τροχοπέδη για την υιοθέτηση ενός υγιεινού τρόπου ζωής, περιορίζοντας έτσι τον αντίκτυπο των προγραμμάτων πρωτοβάθμιας περίθαλψης.

Σκοπός: Σκοπός της παρούσας μελέτης ήταν η διερεύνηση των αντιλήψεων που έχουν οι γονείς αναφορικά με το βάρος τους και το βάρος του παιδιού τους και η ανίχνευση πιθανών διαμεσολαβητών μεταξύ πλήθους κοινωνικοδημογραφικών παραγόντων και μεταβλητών κατάστασης βάρους, σε οικογένειες υψηλού κινδύνου για ΣΔτ2 από έξι ευρωπαϊκές χώρες.

Μεθοδολογία: Τα δεδομένα της παρούσας εργασίας προέρχονται από το συγχρονικό κομμάτι της μελέτης παρέμβασης Feel4Diabetes. Η μελέτη αξιολόγησε 2500 ενήλικες και τα παιδιά τους. Το βάρος και το ύψος τους μετρήθηκαν βάσει τυποποιημένων διαδικασιών. Η αντίληψη για το βάρος αξιολογήθηκε συγκρίνοντας την πραγματική τιμή ΔΜΣ με την απάντηση των γονέων στην ερώτηση "Τι πιστεύετε για το βάρος σας / του παιδιού σας;". Οι πληροφορίες αναφορικά με κοινωνικοδημογραφικές και παραμέτρους του τρόπου ζωής λήφθηκαν με τη χρήση ερωτηματολογίων, ενώ η εκτίμηση του καρδιομεταβολικού κινδύνου έγινε με αιματολογικές εξετάσεις και μέτρηση της αρτηριακής πίεσης.

Αποτελέσματα: Οι βασικότεροι παράγοντες που συσχετίστηκαν θετικά με την υποεκτίμηση του βάρους των ενηλίκων από τους ίδιους ήταν η ανεργία - για τους ενήλικες χαμηλού κινδύνου (ΧΚ) - και το χαμηλό κοινωνικοοικονομικό επίπεδο (ΚΟΚ) και ανδρικό φύλο τόσο για τους ενήλικες ΧΚ όσο και υψηλού κινδύνου (ΥΚ). Όσον αφορά στην υποεκτίμηση του βάρους των παιδιών από τους γονείς τους, οι κυριότεροι παράγοντες για τους ενήλικες ΧΚ ήταν η νεαρότερη ηλικία του παιδιού και το αυξημένο βάρος του παιδιού, ενώ για τους γονείς ΥΚ ήταν η διαμονή σε χώρες της Νοτιοανατολική Ευρώπης, το αρσενικό φύλο του παιδιού και το υπερβάλλον βάρος του παιδιού.

Συμπεράσματα: Η μελέτη έδειξε ότι στους ενήλικες ΥΚ οι κυριότεροι παράγοντες που συσχετίστηκαν με την υποεκτίμηση του βάρους τους ήταν το ΚΟΚ και το φύλο, ενώ αναφορικά με την υποεκτίμηση του βάρους του παιδιού ήταν η περιοχή διαμονής, το φύλο και ο ΔΜΣ του παιδιού. Όλοι οι

προαναφερθέντες παράγοντες θα πρέπει να λαμβάνονται υπόψη κατά τον σχεδιασμό προγραμμάτων πρωτοβάθμιας περίθαλψης προκειμένου να είναι αποτελεσματικά και οικονομικά αποδοτικά.

1.4 Abstract in English

Introduction: Nowadays, worldwide about half a billion people live with diabetes. Type 2 diabetes mellitus (T2DM) is a chronic disease caused by a complex interaction of genetic, epigenetic, lifestyle and environmental factors. One of the main aforementioned risk factors is obesity. As obesity is a modifiable situation, many public health initiatives for the prevention of T2DM focus on its management. However, the question that rises is why so many obesity management programs have failed to accomplish a significant weight loss. Accumulating evidence from the general population propose that obesity epidemic has led to a misconception regarding healthy body weight status, leading a large proportion of adults to inaccurately estimate their own and their offspring's weight status. As a result, weight misperception might inhibit the adoption of a healthy lifestyle, thus limiting the impact of public health initiatives.

Purpose: The purpose of the present study was to investigate the phenomenon of weight misperception by parents regarding their own and their children's weight status and the possible determinants among several sociodemographic and weight status variables, in families at high risk for T2DM in six European countries.

Methodology: The data used in this manuscript derived from the baseline phase of Feel4Diabetes intervention study. The study assessed 2500 adults and their children. Their weight and height were objectively measured using standardized procedures. Weight perception was assessed by comparing their actual BMI value with their answer in the question *"What do you think of your/your child's weight?"*. Sociodemographic and lifestyle parameters were obtained from questionnaires and cardiometabolic risk factors were estimated by blood tests and arterial pressure measurement.

Results: The most dominant factors positively associated with adults' own weight underestimation were unemployment for low risk adults and low SES and male gender for both low and high risk adults. With regards to children's weight underestimation by their parents the most dominant factors among low risk adults were the younger age and the presence of excess weight of the child. In their high risk counterparts the most important factors independently associated with the phenomenon were living in Southeast Europe and having an overweight or obese son.

Conclusions: Our study demonstrated that in high risk adults the most dominant factors independently associated with their own weight underestimation were SES and gender, whereas regarding child's weight underestimation the most dominant factors were living region and the child's gender and BMI. All of the aforementioned factors should be taken into account when designing public health initiatives in order to be efficient and cost effective.

2. Introduction

2.1 Diabetes mellitus

2.1.1 Definition of diabetes mellitus

Diabetes mellitus (DM) is a term used to describe a group of diverse metabolic disorders - mainly characterised by an altered metabolism of carbohydrates, lipids and proteins – which is usually manifested by increased plasma glucose levels. Hyperglycaemia is the result of inadequate insulin secretion (absolute or partial), inability of the target-cells to respond to insulin, or as a combination of the above.[1-3]

2.1.2 Classification of diabetes mellitus

DM can be classified in four main types:

- ***Type 1 Diabetes mellitus (T1DM):*** T1DM is an autoimmune disease leading to gradual pancreatic β-cell destruction and to subsequent absolute insulin deficiency.
- ***Type 2 Diabetes mellitus (T2DM):*** T2DM is a metabolic disorder caused by a gradual loss of β-cell insulin secretion on the background of insulin resistance.
- ***Gestational diabetes mellitus (GDM):*** GDM is the type of diabetes that is diagnosed for the first time during the second or third trimester of pregnancy.
- ***Specific types of diabetes*** due to other causes such as monogenic diabetes syndromes, diseases of the exocrine pancreas and drug- or chemical-induced diabetes.[1, 4]

2.1.3 Prevalence of diabetes mellitus in Europe

Nowadays, worldwide nearly half a billion people live with diabetes with 80% of the cases affecting low and middle income countries. 58.0 million people (8.8% of the population 20-79 years old) suffered from the disease, including 22.0 million undiagnosed cases. By year 2045, it is predicted that the number of diabetic cases will rise to 66.7 million adults mainly due to the ageing European population. Furthermore, Europe has the highest number of children and adolescents (0-19 years) with T1DM worldwide (286,000 cases). Moreover, there is evidence that T2DM tends to affect more widely children and adolescents mainly due to increased rates of childhood obesity and physical inactivity. However, accurate data on T2DM prevalence in European pediatric population are sparse.[1]

2.1.4 Diagnosis of diabetes mellitus – Prediabetes

Diagnostic criteria of T2DM and prediabetes have been proposed by World Health Organization in 2006.[5] T2DM is diagnosed with a fasting plasma glucose ≥ 126 mg/dl or a plasma glucose measurement ≥ 200 mg/dl following an oral glucose tolerance test or a random plasma glucose ≥ 200 mg/dl.[5] The two intermediate states of solely impaired fasting glucose or an impaired glucose tolerance are collectively called "prediabetes" or more accurately "intermediate hyperglycemia", as not everyone with prediabetes is going to develop T2DM. Prediabetes should be treated as a risk factor for the development of T2DM and cardiovascular disease (CVD), rather than a separate clinical entity.[1, 4]

2.1.5 Long term complications of diabetes mellitus

Diabetes induces changes in the microvasculature, causing extracellular matrix protein synthesis, and capillary basement membrane thickening which are the pathognomic features of diabetic microangiopathy, which can lead to macrovascular complications.[6] The main microvascular complications are nephropathy, neuropathy and retinopathy, whereas chronic macrovascular complications include coronary artery disease, peripheral artery disease contributing to stroke, diabetic encephalopathy and diabetic foot ulcers.[1]

2.1.6 Risk factors for the development of type 2 diabetes mellitus

The etiology of T2DM is multifactorial and includes a complex interaction of genetic, epigenetic, lifestyle and environmental factors. The main risk factors strongly associated with the development of T2DM can be classified in modifiable and non-modifiable ones. Non-modifiable risk factors include ethnicity, age, family history of T2DM or CVD, history of CVD or polycystic ovary syndrome, history of GDM or giving birth to an infant weighting > 4 kg, low birth weight or preterm birth of the mother, presence of low grade inflammation, exposure to environmental endocrine disrupters and finally genetic risk factors.[7-9] Modifiable risk factors for the development of T2DM are the presence of excessive weight gain and obesity, hypertension, dyslipidemia, sedentary lifestyle and physical inactivity, poor dietary habits, smoking, alcohol abuse, prediabetes and other pathological states indicating insulin resistance such as metabolic syndrome and acanthosis nigricans.[9-11]

2.2 Body weight and type 2 diabetes mellitus

2.2.1 Body weight and body fat as a risk factor for the development of type 2 diabetes mellitus

Overweight (OW) and obesity are defined by the presence of excess adipose tissue to an extent that it deteriorates both physical and psychosocial health and well-being.[12] The majority of diabetic patients are obese (OB), so the global epidemic of obesity largely explains the dramatic increase in the incidence and prevalence of T2DM over the past 20 years.[13] Both T2DM and obesity are associated with insulin resistance. Any OW or OB person has some kind of insulin resistance, but T2DM only develops in those individuals who lack sufficient insulin secretion to compensate for the reduced insulin sensitivity.[12]

In OB individuals adipose tissue metabolism is upregulated leading to augmented secretion of hormones, glycerol, leptin, cytokines, adiponectin, and proinflammatory substances, and release of nonesterified fatty acids (NEFAs). NEFAs are the cornerstone factor inducing insulin resistance.[12] Besides the strong association between the presence of excess body weight and fat with insulin resistance, another critical factor which further deteriorates insulin sensitivity is body fat distribution. Individuals whose fat distribution is central (especially abdominally) tend to have less insulin sensitivity than their counterparts. Moreover visceral fat has a more intense lipolytic action than subcutaneous fat and exerts a resistance in the antilipolytic action of insulin, leading to further release of NEFAs and subsequently in the deterioration of peripheral organs' insulin sensitivity.[12]

Finally, a recent meta-analysis of Kodama et al. showed that body weight gain in adulthood as well as current obesity status are quantifiable predictors of T2DM. Moreover, body weight gain in early rather than middle-to-late adulthood was suggested to play a critical role in the development of the disease.[14] It is also important to note that nearly one-third of OB adults in the general population are considered metabolically healthy. However, a meta-analysis by Bell et al. reported that this subpopulation of OB individuals show a substantially increased risk of T2DM incident compared with metabolically healthy normal-weight adults.[15]

2.2.2 Perception of adults of their own weight status

As thoroughly described above, excessive body weight is one of the most critical risk factors for the development of T2DM. Accumulating evidence tend to propose that obesity epidemic has led to a

misconception regarding healthy body weight status and body image.[16] Weight misperception might inhibit the adoption of healthful weight-related attitudes and behaviours among OW/OB individuals and could further increase the risk of T2DM development.[17] Data from the *NHANES study* report a significant decline in the probability of self-classifying as OW as years go by. As a result, individuals with excess weight might be less willing to pursue a healthy weight than preciously, thus limiting the impact of public health initiatives. [18] A large proportion of OW and OB people – especially men – have been shown to less accurately perceive their actual weight status. However, this phenomenon is less evident in BMI values above 35 kg/m^2, where 90% of OB people accurately recognise their weight status.[19, 20] Another interesting finding is that weight misperception among OW/OB people has been associated with less attempts of weight loss,[17] while OW perception has been associated with weight control.[20, 21] However, data concerning the association between physical activity and weight misperception are contradictive in a subpopulation of OW/OB subjects. As a matter of fact, performing some physical activity compared to none has been associated with less weight misperception, whereas individuals engaged to high levels of active transportation were more likely to have a distorted perception regarding their weight status. On the other hand, increased levels of sedentary lifestyle in OW/OB individuals seem to be associated with an accurate weight perception.[22] Finally, marital status seems to play a role in weight perception, with married and formerly married women to perceive themselves as OW more frequently.[23]

One more study with US nationally representative sample indicates that about three quarters of the sample's self-perceptions of weight were aligned with their actual BMI,[24] whereas a focused assessment of OB individuals showed that about 50% of them underestimated their weight status.[25] In accordance with these findings, two recent Australian studies demonstrated that 25.5 % of adults underestimated, only 3.8% overestimated their weight,[26] while 26.8% of OW/OB adults misclassified their weight.[27] Male sex and low education level was associated with underestimation, while middle-aged females were more likely to make accurate assumptions regarding their weight status.[26, 27]

Weight perception has also been shown to affect several aspects of behaviour and psychology of adults. In fact weight misperception (both under- and over-) has been associated with low health-related quality of life, self-rated health and general life satisfaction.[28, 29] On the other hand

several “paradoxically positive” effects of weight misperception have been identified. Underestimation of body weight status has been related to less uncontrolled and restrained eating, emotional eating, binge eating, loss of control, distress and eating disorder psychopathology in OW and OB patients.[30, 31] Lastly, the results of KNHANES study (Korea National Health and Nutrition Examination Survey) showed that OB women who underestimate their weight status reported significantly less depressive symptoms compared their accurate perceiving counterparts. On the contrary, women of normal weight (NW) who overestimate their weight status reported more depressive symptoms.[32]

Moving to the European region, several studies have examined the phenomenon of weight misperception. A recent study in Danish population has reported a slight decline in weight misperception rates as years go by.[33] Collectively, accumulating data propose that a considerable proportion of the adult population has a distorted weight self-perception. In further detail, underweight individuals tend to overestimate their weight, whereas OW/OB adults tend to underestimate their weight status as being of “about the right weight”.[34-37] One major drawback of some of these studies is the fact that even the “actual” BMI is calculated based on self-reported values of weight and height and consequently compared with body weight perception.

All of the above studies have highlighted several factors associated with weight misperception. Increasing age and BMI, male sex, low income and level of education, occupation in women, and marital status have been repeatedly associated with altered perceived body image in adults. Moreover, smoking and drinking habits and - with a special focus on OW individuals - poor dietary habits, increased leisure physical activity, “good” self-rated health and the absence of OW/OB diagnosis have been highlighted as possible predisposal factors for self weight misperception.[33-39]

In contrast with the above findings, Nissen et al. in a recent literature review proposed that a considerable proportion of NW individuals perceived themselves as OW, while most OW people accurately perceived their weight status. However, the authors point out that some of the studies included in the analysis lacked methodological quality, thus raising questions about the generalizability of the findings.[40] Finally, a quite recent review in an attempt to detect the

underlying cause for weight misperception has proposed the theory of "visual normalization", where the common presence of larger body sizes has caused a recalibration to the range of body sizes perceived as normal.[16]

2.2.3 Parental perception of children's body weight status

As thoroughly described above, usually adults tend to have an impaired perception of their own weight status and the concomitant health consequences. This phenomenon is even more important in the family setting, as parental perceptions of child's weight status may influence family's readiness to foster healthy behaviours. In fact, quite often parents and grandparents – despite being aware of the cut-offs of growth chart centiles – fail to accurately recognise their offspring's weight status.[41, 42]

Results from the NHANES study report a declining tendency among parents to accurately perceive OW children.[43, 44] In a sample of children aged 8-15 years, 25.2% of parents underestimated and 1.1% overestimated their child's weight status.[45] A subgroup analysis of OB children showed that younger children and boys were more likely to be misperceived as having "about the right weight".[46]

In accordance with this large-scale nationally representative study, several other worldwide studies have demonstrated similar results. In further detail, accumulating evidence also propose that a great proportion of parents misperceive their child's/ adolescent's weight. The weight status of underweight and OW children is usually overestimated and underestimated respectively.[47-54] Multi-year surveys conducted in public schools in the USA showed that this phenomenon is especially escalated among kindergarteners, where 83.9% of parents categorized them as NW, when only 28.3% actually were. Moreover, parents who misperceived their offspring's weight status were approximately 12 times more likely to have an OB child.[54] On the same time, the Taiwan National Health Interview Survey (NHIS) demonstrated that only 1.7% of OW/OB children - whose parents underestimated their weight status - were actually engaged in weight management, indicating a great problem for public health.[50] Finally, Vallejo et al. showed that children whose weight status was underestimated by their mothers were at greater risk of being OW compared to their accurate perceived counterparts.[55] On the other hand, a prospective Australian study

demonstrated that children perceived as OW at 4 years old gained more weight till 13 years old, independently of their actual weight status at baseline.[56]

In accordance with the above, a systematic review conducted in 2012 including studies from all over the world reported that 62.4% of OW children were incorrectly perceived as NW by their parents.[57] Moreover, a later meta-analysis – including a big number of European studies- revealed that 50.7% of parents underestimate their OW/OB offspring's weight, while 14.3% of parents underestimate the weight status of their NW children.[58] With a special focus on the European region, several more recent studies have also emphasized this increased tendency of parental misperception of children's weight status.[59-67] A really interesting finding from the Gateshead Millennium Study is that only if the child's weight was at the extreme end of the OW range or in the OB range, mothers reliably described their weight as OW.[68]

Finally, a cross-sectional study carried out in the UK in a sample of children aged 4-11 years reported that the cut-offs in which parents became more likely to classify their children as underweight (UW) or OW were at ≤0.8th centile and ≥99.7th centile respectively, values that differ significantly from the actual BMI centile cut-offs for UW (2nd centile) and OW (85th centile).[69] However, data from another cross-sectional study with a similar population, report that 41% of parents who perceived their child as OW did not realize the subsequent health-related risks.[70] In fact, in a similar study, although the majority of the parents considered a BMI between 75th and 90th centile a valid reason for their child to engage in an obesity prevention program, 19% of mothers were not willing to engage in prevention until their child reached the 97th centile.[71]

All of the above studies have given further insight into the factors associated with parental weight underestimation. These factors can be classified into child-related and parent-related ones. The most common child-related factors include the younger age,[50, 51, 61, 63, 67] male sex [53, 62, 63, 72] and increased BMI values of the child.[50, 53, 54, 64, 73] Moreover, children of a younger gestational age, with a higher birth weight[74] and a rapid weight gain during infancy are more likely to have their weight status underestimated by their parents.[75] Finally, some less studied factors associated with parental weight misperception include the presence of poor dietary habits,[66] sleep duration, and several aspects of the social and mental health of the child.[61] A few studies have demonstrated opposite results regarding child's sex and age.[60, 74]

Moving to parental characteristics related to the underestimation of their child's weight status some of the most common factors include the younger age of the parent,[50] the male sex of the responding parent[61, 64], occupation of the mother [74], while contradictory results occur regarding the parental education level [64, 67, 74]. Regarding the excess weight of the parent, the majority of the studies report that OW/OB parents have higher rates of misperception of their child's weight, especially if the child is OW/OB itself too. [49, 62, 74] However, several large-scale studies have demonstrated the exact opposite result regarding parental weight, reporting that OW parents are better raters of their OW/OB child's especially if they have an accurate weight self-perception.[61, 65, 76, 77] Finally, parental factors associated with a more accurate perception of their child's weight status include increased cultural capital[72], higher income, the existence of private health insurance and an urban living environment[74]. Moreover, smoking or being on a diet is probably less likely for an adult to misclassify its child's weight status[61]. The majority of the aforementioned factors derive from cross-sectional data, thus they shouldn't be considered as causative factors.

To sum up parental misperception of weight status might be explained by a resistance of parents to stigmatize their children or a tendency to report socially acceptable values towards the mean. Moreover, the underestimation of weight status of an OW/OB child could also be driven by parents' perception that their child will eventually "outgrow" their excess weight or a denial of the situation in order to maintain the established lifestyle habits of the family. Finally, the gender differences in weight perception regarding boys and girls could be a result of gender-different "ideal" body size imposed by social norms.[78]

2.2.4 Perception of parents regarding their own weight and their child's weight in families at high risk for diabetes

As thoroughly described above misperception of weight status is an ever growing phenomenon affecting both the accurate self-weight perception and the parental perception of their offspring's weight status. With a special focus on weight perception among diabetic and prediabetic populations, available scientific data are extremely limited. Studies in samples of OW/OB diabetic adults demonstrate that this subpopulation has also a widely distorted self-image – usually underestimating their weight status – despite the already set diabetes diagnosis.[79-83] Moreover, weight underestimation is especially widespread among OW patients – in accordance with the

findings in healthy subjects. OW patients in the upper limit of OW range and OB diabetics tend to self-identify their weight status more accurately than their OW counterparts.[79, 80] The aforementioned studies demonstrate that diabetics of male gender, with excess weight, low income and that have never been married are more likely to underestimate their weight status category.[80-83] Additionally, the lack of abdominal obesity[80], weight loss attempts[81, 82] and health practitioner counselling [79-82] were also associated with self-weight underestimation· indicating that patients less informed and less engaged to T2DM management are more likely to ignore their actual weight status.

Moving to studies in prediabetic populations, the available data are scarce. A 12-month longitudinal diabetes prevention project conducted in Australia, used a sample of OW/OB subjects at moderate to high risk of T2DM and reported that individuals who highly underperceived their weight status at baseline had greater weight loss at 3 and 12 months of the program.[84] This finding indicates that weight underperception might even exert some "beneficial" effects in the psychology of prediabetic patients, as they don't feel stigmatised and they are more motivated to lose weight.[84]

Moreover another study highlighted that perceiving oneself as OW is associated with greater perceived risk of T2DM and CVD.[85] As long as child's weight is concerned even among a sample of OW/OB children at risk for diabetes – enrolled in a diabetes prevention program – a large proportion of parents failed to accurately identify their child's weight.[86] When accurately estimated, the child's OW status is associated with greater parental perceived risk for T2DM for the child.[87]

2.3 Purpose of the study

Although the aforementioned studies have thoroughly investigated parents' perceptions of their weight and their children's weight compared to the actual body weight status both in healthy and diabetic individuals, there is a major lack of studies regarding weight misperception in families at high risk for T2DM. Thus, the aim of the present study was to investigate the phenomenon of weight misperception by parents regarding their own and their children's weight status and the possible determinants among several sociodemographic and weight status variables, in families at high risk for T2DM in six European countries with different levels of childhood overweight and

obesity. Moreover, we sought to identify the most dominant factors determining adults' perception regarding their own and their offspring's weight status.

3. Methodology

3.1 Study design

The Feel4Diabetes study protocol followed a theoretical framework based on the *PRECEDE-PROCEED* model[88] and the Health Action Process Approach (HAPA) and was registered at https://clinicaltrials.gov/ *(registration number: NCT02393872).*

After finalizing the study protocol and obtaining the necessary approvals from local authorities and bioethics committees, the recruitment of the sample took place in January 2016. Baseline measurements were conducted from April to September 2016. The intervention was implemented within the academic years 2016-2017 and 2017-2018, with each intervention period followed by follow-up measurements in the end of the academic year.

During the implementation phase the intervention was conducted in two different axes. The first one – concerning the "all families" group, included changes in the social and physical environment of the school and home, initiatives from the local stakeholders and a counselling session that provided some general guidelines regarding healthy dietary practices and physical activity. The second axis - concerning the "high risk families" group included seven counselling sessions conducted outside of the school setting and media-based intervention via SMS texts. Process evaluation and assessment of cost-effectiveness were conducted during the implementation phase of the intervention. The data used in this research are derived only from the baseline measurements, so a more detailed description of the intervention remains beyond the scope of this manuscript.

3.2 Ethics approval

The Feel4Diabetes-study adhered to the Declaration of Helsinki and the conventions of the Council of Europe on human rights and biomedicine. All participating countries obtained ethical clearance from the relevant ethical committees and local authorities before the beginning of the intervention. In Greece Feel4Diabetes study protocol was approved by the Bioethics Committee of Harokopio University and the Greek Ministry of Education. All parents/caregivers signed a consent form prior to their enrolment in the study.

3.3 Sample of the study

Feel4Diabetes study's sample included "vulnerable" families from six European countries. "Vulnerable" groups were defined as the population of low/middle income countries (Bulgaria, Hungary), low socioeconomic status (SES) groups in high income countries (Belgium, Finland) and the population of countries in financial crisis (Greece, Spain). In Bulgaria and Hungary, all areas within the selected provinces were considered "vulnerable" and eligible to participate in Feel4Diabetes. In the other four participating countries, the districts in the selected areas were classified in tertiles according to socioeconomic indeces derived from official resources and authorities (e.g. in Greece information was retrieved from the Hellenic Statistical Authority). "Vulnerable" areas were randomly selected from the tertile with the lowest education level or the highest unemployment rate.

In all countries, after obtaining the essential approvals from local authorities, lists of all the primary schools within the selected "vulnerable" areas were created and primary schools were randomly selected from the list. From these primary schools all children attending the first three grades of compulsory education and their families were recruited to the study (i.e. "all families"). The identification of the high-risk families among "all families" (AF) was based on the estimated risk of T2DM risk using the Finnish Diabetes Risk Score (FINDRISC). A family was classified as a "high-risk family" (HRF), in case at least one parent fulfilled the country-specific cut-off point of FINDRISC.[89] The cut-off point for Greece was set at ≥9 points. The final sample of the study included 11,511 "all-families" and 2,230 "high-risk families", obtained by a total of 236 primary schools in all six participating countries.

3.4 Measurements

At baseline a series of anthropometric measurements and assessment of blood pressure and several blood indices were conducted. Moreover, a series of questionnaires regarding both the parents/caregivers and the children were filled in. In the next lines a more detailed description of some of the aforementioned measurements - with a special focus on the present analysis -is presented.

1) Anthropometric measurements:

Weight of parents and children: Weight assessment was conducted with a certified electronic scale *(SECA 813, SECA 877)*. The measurement was carried out in a lined straight position, barefoot, with the minimum possible cloth items. Each time the measured value was rounded up to the closest 0,1Kg. The measurement was conducted twice, while in case of deviation > 100 g, a third measurement was taken. In case of denial, a weight exceeding the scale's measurable range or an objective barrier (p.e wheelchair) the measurement was not conducted.

Height of parents and children: Height was determined with a portable stadiometer *(SECA 214, SECA 217, SECA 213, SECA 225)*. The measurement was carried out in a lined straight position, barefoot, with no hair accessories or tied up hair. The head was placed in the Frankfort horizontal plane by the researcher. The measurement was conducted twice, while in case of deviation > 1 cm, a third measurement was taken. In case of denial or an objective barrier (p.e wheelchair) the measurement was not conducted.

BMI estimation of parents and children: The mean values or weight and height were used in order to estimate participant's BMI. BMI was calculated using Quetelet's equation (BMI = Weight (kg) / (Height)^2 (m^2). The classification of weight status for the adults was done based on WHO criteria[90] and for the children based on the International Obesity Task Force (IOTF) cutoff points.[91]

Waist circumference in adults: Waist circumference was taken with a non-extendible measuring tape at the midway of the top of the hip bone and the bottom of your ribs. The measurement was carried out in a lined straight position, with the minimum possible cloth items (removal of cloth items that change body shape such as tights, belt etc.), in bare skin. Each time the measured value was rounded up to the closest 0,1cm. The measurement was conducted twice, while in case of deviation >1 cm, a third measurement was taken. In case of denial, a waist circumference exceeding the measuring tape's length or an objective barrier the measurement was not conducted. Participants were classified based on their waist circumference to having a low, moderate or high health risk according to WHO criteria.[90]

2) Determination of cardiometabolic risk factors in parents:

Also, the parents of high risk families underwent blood tests - for the determination of their lipidemic profile and glucose metabolism - and blood pressure measurement according to standard proceedures offering high validity of the results.[5, 92]

3) Questionnaires:

FINDRISK Score: At the beginning of the study parents/caregivers were asked to fill in the FINDRISK Score in order to be classified in "all families" or "high-risk family" component of the intervention. FINDRISK Score included nine questions regarding: 1) age, 2) body weight, 3) height, 4) waist circumference, 5) the presence of 30 minutes of daily physical activity, 6) the daily consumption of fruits and vegetables, 7) history of antihypertensive medication, 8) history of increased plasma glucose levels and 9) family history of T2DM. As mentioned previously a family was classified as a "high-risk family", if at least one parent fulfilled the country-specific cut-off point, which was set at ≥9 points for Greek participants.

Data regarding demographic information, SES and level of education were also collected. Moreover, parents provided information on their own and their child's dietary and physical activity habits, eating behaviours, sleep duration, physical activity, sedentary behaviours and the presence of electronic devices in their child's bedroom. Finally, the medical history of high-risk families was thoroughly assessed.

Weight perception: In the aforementioned questionnaires parents also answered what did they think of their own and their child's weight among the following options: 1) Weight is way too low 2) Weight is a bit too low 3) Weight is not too low, not too high 4) Weight is a bit too high and 5) Weight is way too high. These answers were matched to the following perceived BMI categories: 1)-2) → UW (Perceived), 3) → NW (Perceived), 4) → OW (Perceived), 5) → OB (Perceived). Finally, the perceived BMI values were compared to the objectively measured BMI values of participating parents and children in order to investigate whether the subjects underestimated, overestimated or accurately estimated their own and their offspring's weight status.

3.5 Statistics

The statistical software package IBM SPSS Statistics version 21.0 (SPSS: Statistical Package for Social Sciences, SPSS Inc., Chicago, IL, USA) was used for all statistical analyses. The level of statistical significance was set at $P<0.05$. Categorical variables were summarized as relative

frequencies (%) and continuous variables are presented as mean ± standard deviation. Associations between categorical variables were assessed using the χ^2 (chi square) test. Moreover, multilevel (univariate and multivariate) logistic regression analyses were performed, so as to assess the statistical significance of the associations of sociodemographic and other characteristics with parental underestimation of their own and their children's weight status (dependent variables). The aforementioned results are presented as odds ratios (OR) and 95% confidence intervals (CI). All reported p values were based on two-sided tests.

4. Results

Participant Characteristics

The study sample consisted of 2500 parents. Of them 890 participants were identified as high risk and 1500 as low risk adults according to the FINDRISK score with score 12 being the threshold for this categorization. 35.5% of the sample were OW and 36.5% OB. A more detailed presentation of participants' baseline characteristics is shown in Table 1.

Table 1: Baseline characteristics of the study's sample

Variables		Total (N=2500)	FINDRISK<12 (N=1550)	FINDRISK≥12 (N= 890)
Gender				
	Female	66.3%	66.7%	66.9%
	Male	33.7%	33.3%	33.1%
Age category				
	<45 years	76.1%	81.7%	66.4%
	>45 years	23.9%	18.3%	33.6%
Region				
	Central north Europe[(1)]	28.5%	28.1%	29.2%
	Southeast Europe[(2)]	71.5%	71.9%	70.8%
SES (Years of education)				
	0-14 years	40.6%	38.7%	42.5%
	>15 years	59.4%	61.3%	57.5%
Findrisc score		10.27 (±4.06)	7.98 (±2.96)	14.23 (±2.25)
Waist circumference (cm)		94.68 (±14.30)	91.20 (±13.49)	100.88 (±13.62)
BMI Category				
	Underweight	0.6%	0.8%	0.2%
	Normal weight	27.4%	36.7%	11.1%
	Overweight	35.5%	37.1%	32.3%
	Obese	36.5%	25.4%	56.4%
Physical activity (Walking min/day)		64.96 (±105.91)	66.22 (±105.55)	64.68 (±109.28)
Sedentary behaviour (Sitting hours/day)		5.35 (±3.35)	5.26 (±3.34)	5.52 (±3.37)
Total Cholesterol (mg/dL)		194.39 (±37.65)	192.33 (±36.79)	198.23 (±38.67)
LDL - Cholesterol (mg/dL)		120.58 (±32.88)	118.21 (±32.36)	124.54 (±33.25)
HDL - Cholesterol (mg/dL)		53.12 (±13.95)	54.56 (±14.46)	50.94 (±12.70)
Triglycerides (mg/dL)		109.17 (±85.07)	101.71 (±72.12)	122.82 (±104.39)
Glucose (mmol/L)		5.26 (±0.78)	5.17 (±0.66)	5.43 (±0.94)
Hypertension				
	No	50%	55.2%	41.4%
	Yes	50%	44.8%	58,6%
Adults' weight misperception by themselves				
	Overestimation	18.4%	21.4%	13.7%
	Accurate perception	64.5%	61.8%	68.7%
	Underestimation	17.1%	16.8%	17.6%
Children's weight misperception by their parents				
	Overestimation	4.7%	5%	4.6%
	Accurate perception	66.5%	67.6%	65%
	Underestimation	28.8%	27.4%	30.4%

[(1)]*Central north Europe: Belgium, Finland* [(2)]*Southeast Europe: Spain, Greece, Hungary, Bulgaria*

Perception of adults' weight status by themselves:

Regarding low risk adults; perception of their own weight status is presented in Table 2. It was shown that adults living in Southeast Europe were less likely to accurately estimate and more likely to overestimate their weight status compared to those living in Central north Europe. Moreover, adults of a higher SES more accurately perceived their actual weight status compared to their low SES counterparts. Finally, male participants underestimated, whereas women overestimated their weight status.

Regarding perception of high risk adults' weight status by themselves, it was shown that a quarter of high risk men underestimated their actual weight, while a significant proportion of women overestimated their weight status (*data presented in Table 3*).

Perception of children's weight status by their parents:

Regarding low risk participant's parental perceptions of their offspring's weight status, parents of a higher SES more accurately estimate their child's actual weight. Furthermore, younger children's weight was more underestimated compared to their older counterparts. Also, parents of girls overestimated their weight compared to parents of boys. Also UW children were overestimated by their parents, while more than half of parents with an OW/OB child underestimated its weight. Also, NW children had the largest proportion of accurate weight estimation by their parents. Finally, NW adults made the most accurate assumptions, whereas OB parents widely underestimated their child's weight status. Parents who underestimated their own weight status were found to also largely underestimate their child's weight status (*data presented in Table 2*).

As regards to perception of children's weight status by their parents in high risk group, parents living in Southeast Europe were more likely to have underestimated their child's weight, compared to those living in Central north Europe. Moreover, OB parents underestimated their offspring's weight in a larger proportion than their OW counterparts. Regarding the child's actual weight, NW children were more likely to be accurately perceived, while UW children's status was largely overestimated by their parents. Finally, the greater the weight of the child, the bigger the proportions of parental weight underestimation (*data presented in Table 3*).

Table 2: Chi square tests investigating the associations between sociodemographic and weight status variables with parental underestimation of their own and their children's weight status in low risk subsample.

	Perception **of adults' weight status** by themselves						Perception of **children's weight status** by their parents					
Low-risk parents	Underestimation		Accurate perception		Overestimation		Underestimation		Accurate perception		Overestimation	
	n	%	n	%	n	%	n	%	n	%	n	%
Region												
Central north Europe[1]	39	12.4%	213	**67.8%**[b]	62	**19.7%**[c]	72	22.6%	231	72.4%	16	5.0%
Southeast Europe[2]	95	12.8%	437	**58.7%**[b]	213	**28.6%**[c]	219	28.5%	504	65.5%	46	6.0%
p				**0.008**						0.087		
SES												
0-14 years of education	63	**15.8%**[a]	226	**56.8%**[b]	109	27.4%	141	**33.7%**[d]	255	**60.9%**[e]	23	5.5%
> 15 years of education	71	**10.7%**[a]	424	**64.1%**[b]	166	25.1%	150	**22.4%**[d]	480	**71.7%**[e]	39	5.8%
p				**0.021**						**0.000**		
Marital status												
Single family	10	12.8%	53	67.9%	15	19.2%	28	35.0%	45	56.3%	7	8.8%
Dual family	124	12.7%	596	60.9%	259	26.5%	263	26.1%	689	68.4%	55	5.5%
p				0.360						0.074		
Occupation												
Employed	95	11.8%	505	62.7%	206	25.6%	212	25.7%	564	68.3%	50	6.1%
Unemployed	39	15.8%	140	56.7%	68	27.5%	78	30.5%	166	64.8%	12	4.7%
p				0.152						0.264		
Parental age												
<45 years old	107	12.0%	553	62.2%	229	25.8%	249	27.2%	616	67.2%	52	5.7%
>45 years old	27	15.9%	97	57.1%	46	27.1%	42	24.6%	119	69.6%	10	5.8%
p				0.305						0.781		
Child's age												
6-7 years old							154	**29.5%**[d]	347	66.5%	21	**4.0%**[f]
8-9 years old							137	**24.2%**[d]	388	68.6%	41	**7.2%**[f]
p										**0.019**		
Parental gender												
Male	45	**30.6%**[a]	87	59.2%	15	**10.2%**[c]	43	27.6%	106	67.9%	7	4.5%
Female	89	**9.8%**[a]	563	61.7%	260	**28.5%**[c]	248	26.6%	629	67.5%	55	5.9%
p				**0.000**						0.772		
Child's gender												
Boy							145	27.5%	363	68.9%	19	**3.6%**[f]
Girl							146	26.0%	372	66.3%	43	**7.7%**[f]
p										**0.015**		

Parental BMI							
Underweight		2	22.2%	6	66.7%	1	11.1%
Normal weight		102	**22.0%**[(g)]	339	**73.2%**[(i)]	22	4.8%
Overweight		95	**26.0%**[(h)]	246	67.2%	25	6.8%
Obese		82	**36.9%**[(g) (h)]	133	**59.9%**[(i)]	7	3.2%
p					**0.002**		
Child's BMI							
Underweight		0	0.0%	30	**55.6%**[(l) (m)]	24	**44.4%**[(p) (q)]
Normal weight		122	**16.5%**[(j) (k)]	588	**79.5%**[(m) (n) (o)]	30	**4.1%**[(p)]
Overweight		115	**53.5%**[(j)]	92	**42.8%**[(n)]	8	**3.7%**[(q)]
Obese		54	**68.4%**[(k)]	25	**31.6%**[(l) (o)]	0	0.0%
p					**0.000**		
Perception of adults' weight status by themselves							
Underestimation		50	**37.3%**[(r) (s)]	79	59.0%	5	3.7%
Accurate perception		162	**25.4%**[(r)]	442	69.2%	35	5.5%
Overestimation		66	**24.2%**[(s)]	192	70.3%	15	5.5%
p					**0.052**		

[(letter)]: Statistically significant difference between the categories of the independent value.

[(1)]*Central north Europe: Belgium, Finland* [(2)]*Southeast Europe: Spain, Greece, Hungary, Bulgaria*

Table 3: Chi square tests investigating the associations between sociodemographic and weight status variables with parental underestimation of their own and their children's weight status in high risk subsample.

	Perception **of adults' weight status** by themselves						Perception of **children's weight status** by their parents					
High-risk parents	Underestimation		Accurate perception		Overestimation		Underestimation		Accurate perception		Overestimation	
	n	%	n	%	n	%	n	%	n	%	n	%
Region												
Central north Europe[1]	24	11.6%	150	72.5%	33	15.9%	38	**18.0%**[c]	158	**74.9%**[d]	15	7.1%
Southeast Europe[2]	55	14.3%	268	69.8%	61	15.9%	154	**37.4%**[c]	241	**58.5%**[d]	17	4.1%
p				0.642						**0.000**		
SES												
0-14 years of education	38	16.9%	148	65.8%	39	17.3%	81	32.4%	158	63.2%	11	4.4%
> 15 years of education	41	11.2%	270	73.8%	55	15.0%	111	29.8%	241	64.6%	21	5.6%
p				0.078						0.662		
Marital status												
Single family	9	19.6%	33	71.7%	4	8.7%	18	33.3%	33	61.1%	3	5.6%
Dual family	70	12.8%	385	70.6%	90	16.5%	174	30.6%	366	64.3%	29	5.1%
p				0.215						0.895		
Occupation												
Employed	54	13.1%	299	72.4%	60	14.5%	124	29.0%	277	64.9%	26	6.1%
Unemployed	24	13.7%	119	68.0%	32	18.3%	65	34.0%	120	62.8%	6	3.1%
p				0.477						0.185		
Parental age												
<45 years old	54	12.6%	306	71.3%	69	16.1%	139	30.6%	293	64.5%	22	4.8%
>45 years old	25	15.4%	112	69.1%	25	15.4%	53	31.4%	106	62.7%	10	5.9%
p				0.663						0.835		
Child's age												
6-7 years old							87	30.3%	186	64.8%	14	4.9%
8-9 years old							105	31.3%	213	63.4%	18	5.4%
p										0.922		
Parental gender												
Male	19	**25.3%**[a]	53	70.7%	3	**4.0%**[b]	20	25.3%	52	65.8%	7	8.9%
Female	60	**11.6%**[a]	365	70.7%	91	**17.6%**[b]	172	31.6%	347	63.8%	25	4.6%
p				**0.000**						0.185		
Child's gender												
Boy							96	32.2%	183	61.4%	19	6.4%
Girl							96	29.5%	216	66.5%	13	4.0%
p										0.261		

Parental BMI							
Underweight		0	0.0%	2	100.0%	0	0.0%
Normal weight		19	22.9%	55	66.3%	9	**10.8%**[f]
Overweight		48	**25.4%**[e]	132	69.8%	9	4.8%
Obese		114	**36.1%**[e]	191	60.4%	11	**3.5%**[f]
p					**0.012**		
Child's BMI							
Underweight		0	0.0%	9	**45.0%**[j] [k]	11	**55.0%**[o] [p]
Normal weight		71	**17.6%**[g] [h]	316	**78.4%**[k] [l] [m]	16	**4.0%**[o]
Overweight		60	**47.2%**[g] [i]	62	**48.8%**[l] [n]	5	**3.9%**[p]
Obese		61	**83.6%**[h] [i]	12	**16.4%**[j] [m] [n]	0	0.0%
p					**0.000**		
Perception of adults' weight status by themselves							
Underestimation		26	34.2%	44	57.9%	6	7.9%
Accurate perception		126	30.6%	267	64.8%	19	4.6%
Overestimation		26	27.7%	64	68.1%	4	4.3%
p					0.591		

[letter]: Statistically significant difference between the categories of the independent value.

[1]*Central north Europe: Belgium, Finland* [2]*Southeast Europe: Spain, Greece, Hungary, Bulgaria*

Multivariate logistic regression models:

Perception of adults' weight status by themselves:

In the multivariate logistic regression model in low risk participants, it was shown that the most dominant factors independently associated with adults' perception of their own weight status were SES, occupation status and gender. In specific, unemployed, low SES men have the highest risk to underestimate their own weight status (*data presented in Table 4*). Regarding the high risk subsample, high SES and female gender were inversely associated with the underestimation of adults' weight status (*data presented in Table 5*) independently from all other variables tested.

Perception of children's weight status by their parents:

Regarding perception of children's weight status by their parents in low risk group, it was shown that parents of older children were less likely to have underestimated their offspring's weight. Moreover, OW and OB children were approximately 6.4 and 17.6 times respectively, more likely to have their weight underestimated, compared to their UW and NW counterparts (*data presented in Table 4*). On the other hand, high risk parents living in Southeast Europe were more likely to have underestimated their child's weight, while having a girl was associated with a lower relative risk of underestimation. Lastly, OW and OB children's weight was about 5.3 and 26.6 times respectively, more underestimated by their parents, compared to UW and NW children (*data presented in Table 5*).

Table 4: Odds ratios and 95 % confidence intervals resulting from multilevel binary multiple logistic regression analyses assessing the relationship between parental underestimation of their own and their children's weight status and sociodemographic and weight status variables in low risk subsample.

	Dependent variable: Underestimation of adults' weight status by themselves		Dependent variable: Underestimation of children's' weight status by their parents	
Low-risk parents	Adjusted OR*	95% CI	Adjusted OR*	95% CI p
Region				
Central north Europe[(1)]	1.00	Ref	1.00	Ref
Southeast Europe[(2)]	1.29	0.84-1.99	1.04	0.69-1.57
SES				
0-14 years of education	1.00	Ref	1.00	Ref
> 15 years of education	**0.66**	**0.45-0.97**	0.74	0.50-1.08
Marital status				
Single family	1.00	Ref	1.00	Ref
Dual family	1.00	0.48-2.06	0.68	0.36-1.30
Occupation				
Employed	1.00	Ref	1.00	Ref
Unemployed	**1.65**	**1.06-2.56**	1.13	0.73-1.76
Parental age				
<45 years old	1.00	Ref	1.00	Ref
>45 years old	1.00	0.60-1.66	0.80	0.47-1.36
Child's age				
6-7 years old			1.00	Ref
8-9 years old			**0.66**	**0.45-0.96**
Parental gender				
Male	1.00	Ref	1.00	Ref
Female	**0.27**	**0.17-0.43**	0.83	0.49-1.40
Child's gender				
Boy			1.00	Ref
Girl			0.90	0.62-1.31
Parental BMI				
Underweight & Normal weight			1.00	Ref
Overweight			1.29	0.82-2.05
Obese			1.45	0.89-2.36
Child's BMI				
Underweight & Normal weight			1.00	Ref
Overweight			**6.38**	**4.17-9.78**
Obese			**17.58**	**8.93-34.61**
Perception of adults of their own weight status				
Accurate perception			1.00	Ref
Underestimation			1.26	0.78-2.05

Ref: Referent category
Statistically significant odds ratios are indicated in bold font.
**Adjusted for all other independent variables included in the multivariate logistic regression models.*
[(1)]*Central north Europe: Belgium, Finland* [(2)]*Southeast Europe: Spain, Greece, Hungary, Bulgaria*

Table 5: Odds ratios and 95 % confidence intervals resulting from multilevel binary multiple logistic regression analyses assessing the relationship between parental underestimation of their own and their children's weight status and sociodemographic and weight status variables in high risk subsample.

	Dependent variable: Underestimation of adults' weight status by themselves		Dependent variable: Underestimation of children's' weight status by their parents	
High-risk parents	Adjusted OR*	95% CI	Adjusted OR*	95% CI
Region				
Central north Europe[(1)]	1.00	Ref	1.00	Ref
Southeast Europe[(2)]	1.26	0.74-2.14	**1.91**	**1.14-3.20**
SES				
0-14 years of education	1.00	Ref	1.00	Ref
> 15 years of education	**0.59**	**0.35-0.98**	1.26	0.76-2.10
Marital status				
Single family	1.00	Ref	1.00	Ref
Dual family	0.63	0.28-1.41	1.18	0.51-2.69
Occupation				
Employed	1.00	Ref	1.00	Ref
Unemployed	1.08	0.62-1.89	0.75	0.44-1.29
Parental age				
<45 years old	1.00	Ref	1.00	Ref
>45 years old	1.21	0.70-2.10	1.07	0.63-1.80
Child's age				
6-7 years old			1.00	Ref
8-9 years old			0.91	0.57-1.47
Parental gender				
Male	1.00	Ref	1.00	Ref
Female	**0.41**	**0.22-0.77**	1.08	0.54-2.15
Child's gender				
Boy			1.00	Ref
Girl			**0.62**	**0.39-1.00**
Parental BMI				
Underweight & Normal weight			1.00	Ref
Overweight			0.94	0.37-2.40
Obese			1.02	0.42-2.47
Child's BMI				
Underweight & Normal weight			1.00	Ref
Overweight			**5.27**	**3.10-8.95**
Obese			**26.58**	**11.86-59.57**
Perception of adults of their own weight status				
Accurate perception			1.00	Ref
Underestimation			1.23	0.65-2.33

Ref: Referent category
Statistically significant odds ratios are indicated in bold font.
**Adjusted for all other independent variables included in the multivariate logistic regression models.*
[(1)]*Central north Europe: Belgium, Finland* [(2)]*Southeast Europe: Spain, Greece, Hungary, Bulgaria*

5. Discussion

The present study sought to investigate the perceptions of parents regarding their own and their children's weight status and to highlight the factors associated to weight misperception, in families at high risk for T2DM in six European countries participating in the Feel4Diabetes project.

Distorted self-perceived body image in adults is a topic thoroughly studied in the general population. Our study showed that a great proportion of adults – at both low and high risk for T2DM – misperceived their actual weight status, a finding in line with several other large scale studies on the field.[24, 26, 34, 37] Low risk adults living in Southeast Europe were found to less accurately estimate and widely overestimate their actual weight compared to those living in Central north Europe. Moreover, a higher SES was associated with more accurate estimations of adults' actual weight status compared to a lower SES. Finally, a factor strongly associated with self-weight misperception in both low and high risk adults is gender. In specific, in both subgroups, male participants highly underestimated, whereas women overestimated their actual weight status. On the same time, in the multivariate logistic regression model the most dominant factors independently and positively associated with adults' own weight underestimation were unemployment for low risk adults and low SES and male gender for both low and high risk adults. Unfortunately no studies have investigated the factors associated with weight misperception in adults in a high risk population. However, data from healthy and diabetics patients support our findings.[26, 27, 36-39, 80, 81, 83] To sum up, weight misperception has been proposed to be a result of "visual normalization", a theory proposing that the common presence of larger body sizes has led to a concomitant recalibration of the range of body sizes perceived as normal.[16]

On the same time, our study suggested that about one third of the participating parents misperceived – mainly underestimated – their children's weight status. This finding has been widely described in large studies such as the NHANES and a recent meta-analysis including also a large number of European studies.[45, 58] With a special focus on low risk participants, parents of a lower SES underestimated their children's weight more than their higher SES counterparts. Moreover, younger children were more underestimated compared to older ones, whereas girls' weight status was twice as overestimated compared to boys. Furthermore, UW children were

overestimated by their parents, while more than half of parents with an OW/OB child underestimated its weight, indicating a tendency of the parents to report socially acceptable values towards the mean – a behaviour well described in available scientific literature.[78] Finally, OW/OB parents and parents who underestimated their own weight status, widely underestimated their child's weight status. Moving to high risk participants, parents living in Southeast Europe underestimated their child's weight in a larger proportion than those living in Central north Europe. Regarding the BMI of the child and the parent, the same tendencies as described in low risk participants were observed. The multivariate regression model carried out in the low risk subsample proposed as the predominant factors associated with children's weight parental underestimation the younger age and the presence of excess weight of the child. In their high risk counterparts the most important factors independently associated with the phenomenon were living in Southeast Europe and having an OW/OB son. All of the above associations have been previously described by other research teams in healthy population, whereas our results are obtained from high risk families. [46, 49, 50, 57, 58, 61, 62, 64, 74] The novel finding in our study was that low risk parents who underestimated their own weight status were also found to underestimate their child's weight status in a great extent. Collectively, the current literature proposes that parental misperception of child's weight could be attributed to a denial of parents to stigmatize their children, a tendency to be socially acceptable, the wrong impression that the excess weight will eventually "outgrow", or a resistance to change their family established habits.[78]

The present study has both certain strengths and limitations. One of the major strengths of the study is that it has a large sample obtained from 6 European countries, while the researchers used strictly standardized procedures. In fact, this is one of the few studies that have used objectively measured values of weight and height – instead of self-reported ones – to investigate the phenomenon of weight misperception. Finally, this is a quite novel study in the field as weight misperception has been so far investigated in the general population or in diabetic patients. As a result, this study comes to give the first insight in the phenomenon of weight status misperception of adults at high risk for T2DM regarding their own and their children's weight status. Regarding limitations, the data of our study derive from the cross-sectional part of Feel4Diabetes project, so the associations presented above should not be interpreted as causative relationships. Moreover,

in participant's answers there is always the underlying risk of prestige bias. In specific, even participants that accurately perceive their weight condition might over- or under-report due to social desirability reasons. Finally, the perception of weight status was assessed with only one question - thoroughly described in the methodology. So the question that rises is whether a sole question is enough to investigate the studied behaviour.

Our study demonstrated that in high risk adults the most dominant factors independently associated with their own weight underestimation were SES and gender, whereas regarding child's weight underestimation the most dominant factors were living region and the child's gender and BMI. These findings are extremely important when trying to design awareness programs and public health initiatives. These projects should take into account the impact of the aforementioned factors and focus on prevention programs and efficient management of the phenomenon, as weight misperception precludes the effective management of obesity – a critical risk factor for the development of T2DM. In further detail, as long as family based interventions are concerned, the parental denial of the child's actual weight status poses a great barrier and affects the efficacy of the intervention no matter how well designed it is.

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