

# Physical and Psychological Well-Being in Overweight Children Participating in a Long-Term Intervention Based on Judo Practice

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## Abstract

There is an increase of inactivity and overweight in children and adolescents which has a negative impact on their physical, motoric, emotional and cognitive development. This study examines changes in physical fitness and psychological well-being after participation in an intervention program offering a weekly professionally guided judo practice especially for overweight and obese children and adolescents. 26 overweight or obese children and adolescents (age 7 - 14) completed on average 28 sessions of judo training over a course of 12 months. Subjects completed a physical examination (stability, body composition, leg strength) and an assessment of psychological well-being (health-related quality of life, mental health problems) prior to entering the study, after 6 months and after completion of the training. We found significant changes in stability ( $p < .001$ ), fat free mass ( $p = .001$ ), leg strength (left  $p = .022$ , right  $p = .019$ ), mental health problems ( $p < .001$ ), conduct problems ( $p < .001$ ) and peer problems ( $p < .001$ ) and a trend in health-related quality of life ( $p = .055$ ). Participants that dropped out ( $n = 12$ ) showed a significantly higher BMI ( $p = .018$ ) and higher scores in peer problems ( $p = .004$ ). This study indicates that judo practice could have an influence on physical and psychological variables in overweight and obese children and adolescents. Judo provides a way to introduce regular physical activity among overweight and obese children and adolescents to support a more active lifestyle. We observed significant

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changes in physical fitness and psychological well-being in obese children after one year of judo practice. Approaches to support obese children in developing a more active lifestyle are of great significance.

### **Keywords**

Childhood Obesity, Exercise Intervention, Physical Performance, Mental Health, Judo

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## **1. Introduction**

The prevalence of inactivity, overweight and obesity among children is continually increasing and has a negative impact on the physical, motoric, emotional and cognitive development (Graf, Dordel, Koch, & Predel, 2006). Several causes contributing to the rising prevalence of childhood obesity have been identified: genetic predispositions, lifestyle, urbanization, technological development and the increasing amount of media consumption. There is an upward trend of physical inactivity among children in primary school: in the 1970s children aged between six and ten years used to be physically active for three to four hours per day, currently children are active for less than one hour (Bös, Opper, & Woll, 2002; Manz et al., 2014) and watch on average over 2 hours television per day (Froiland & Davidson, 2016a).

The term overweight describes an increased body weight in relation to body height that is above age and gender norms. Severe overweight is referred to as obesity. It is characterized by an excessive amount of body fat and increasing risk for medical conditions (Warschburger & Petermann, 2007). The medical and social consequences of obesity and inactivity among children are complex and contribute to unhealthy behaviors and physical inactivity during adulthood (Graf et al., 2004). Overweight and obesity are related to long-term health conditions: e.g. the metabolic syndrome and cardiovascular disorders (Lu et al., 2013). Furthermore, obese children tend to become obese adults (Guo, Wu, Chumlea, & Roche, 2002). In comparison to normal weight children obese children and adolescents also suffer from more consequences on psychosocial health. Mainly a reduced quality of life (Ottova, Erhart, Rajmil, Dettenborn-Betz, & Ravens-Sieberer, 2012) and social isolation (Strauss & Pollack, 2003) have been documented. Moreover, obese children report a lower self-esteem (Griffiths, Parsons, & Hill, 2010; Petracci & Cavrini, 2013) and more frequently suffer from depressive disorders (Blaine, 2008).

In Germany 15 percent of children and adolescents aged 3 to 17 are overweight. More than one third of these are obese. This equates to about 1.9 million overweight children and adolescents, including 800,000 being obese (Kurth & Rosario, 2007).

Systematic reviews and meta-analyses on effects of lifestyle interventions on childhood obesity report only small impacts on weight loss (McGovern et al.,

2008; Oude et al., 2009). Ho et al. (2012) showed in a systematic review that lifestyle interventions (n = 83 RCTs) lead to a significant weight loss compared with a no-treatment control group ( $-1.25 \text{ kg/m}^2$ ; 95%-CI:  $-2.18$ ;  $-0.32$ ). Accordingly positive effects were found in a one year structured outpatient training program consisting of physical exercises one to two times per week, nutritional education and behavior therapy in 132 obese children. After one year 74% of all participants managed to reduce their weight (mean reduction of BMI) and 34% were no longer classified as obese at the end of the training. In addition to the impact on anthropometric parameters the study also documented improvements in self-esteem, acceptance among peers and attractiveness (Reinehr et al., 2005). Another one-year exercise and lifestyle intervention with 124 obese children combined physical activity (1-2x per week endurance and resistance training), diet counseling, psychological coaching and education about the medical background of obesity and reported significant decreases in BMI and body fat (Blüher et al., 2014).

The practice of judo challenges the individual on different levels. It combines strength, physical fitness, speed, flexibility, judo techniques and coordination. Especially obese children can obtain advantages from their body weight when performing different judo techniques and as a result gain self-confidence and achieve success. Moreover, besides improving physical fitness judo also conveys precious values. Central elements of judo are values like honesty, friendship, willingness to help, courage, discipline and respect (Barth & Wiennecke, 2012).

Primary goal of the present study is to measure changes in physical fitness (postural stability, body composition, leg strength) and psychological well-being (mental health problems, quality of life) of overweight children participating in a weekly judo practice over a course of 12 month. Whether judo training can lead to improvements in weight and body composition in a group of obese children has not been tested yet. Effects of judo were shown on physical coordination and body sway in adolescents with multiple impairments and on psychological variables in interventions targeting anger and aggressiveness (Gleser, Nyska, Porat, Margulies, Mendelberg, & Wertmann, 1992; May, Baumann, Worms, Koring, & Aring, 2001).

## 2. Methods

### 2.1. Study Design and Patient Recruitment

In a non-randomized, single arm pilot study data was collected longitudinally prior to the training (t1), after six months of training (t2) and after completion of the one-year training period (t3). As a feasibility study a control group was not included. 41 obese/overweight children/adolescents were recruited through different pediatrician practices, obese and overweight specialized treatment institutions, schools, as well as through advertisements in newspapers and a television report from a local broadcaster. The trial was approved by the ethics committee of the Chamber of Physicians, City of Hamburg, Germany (Registration

Number PV 4117). Informed consent was obtained for all participating children by their parents.

## 2.2. Inclusion and Exclusion Criteria

All recruited patients had to meet the following criteria: 1) age between seven and 14 years and 2) an age-based BMI classified  $\geq 90^{\text{th}}$  percentile. Overweight and obesity were classified using the sex and age-specific percentile curves for BMI. (Overweight: at or above the  $90^{\text{th}}$  percentile, obesity: at or above  $97^{\text{th}}$  percentile (Kromeyer et al., 2001)). Patients were excluded if they had any medical contraindication for exercise therapy (such as asthma, cardiovascular or orthopedic abnormalities).

## 2.3. Exercise Program

All subjects participated in a weekly judo-training lasting one hour. The supervised training session was directed by a professional judo coach provided by the Hamburg judo association. Training sessions are divided into two parts: a phase of warming-up with playful elements and exercises focusing on endurance and flexibility skills and a second phase including judo-specific throwing and grappling techniques. The training integrates individual exercise and partner exercises. Training was conducted in three different groups ( $n_1 = 10$ ,  $n_2 = 8$ ,  $n_3 = 8$ ) with three different judo coaches.

## 2.4. Assessment Methods

Subjects completed a physical examination (stability, body composition, leg strength) and psychological well-being was assessed via questionnaires measuring health-related quality of life and behavioral problems prior to entering the study, after six month and after completion of the training.

### 2.4.1. Postural Stability (MFT S3-Check)

Postural stability, balance and sensorimotor regulation function were determined using the MFT S3-Check, which is a common and well-established testing system (Raschner, Lembert, Platzer, Patterson, Hilden, & Lutz, 2008). Subjects were instructed to remove their shoes and position their feet on an unstable uniaxial platform. The platform can be tilted by up to  $12^\circ$  in the directions “front/back” (f/b) and “right/left” (r/l) and is captured by a sensor. Subjects are instructed to hold the plate in a horizontal position. Magnitude and number of movements are measured and summarized in the sensorimotor index. Variations from the center of the plate are summarized in the symmetry index. Based on a calculation of both parameters the stability index provides a quantitative measure of the complex balance ability. Both test directions were conducted and for each test direction the system calculated the *stability index (stability f/b, stability r/l)*. Values vary between 1 (very good) and 9 (very poor). In general, values between 1 and 3 reflect a very good, values between 3 to 5 an average and values between 5 and 9 a very poor performance (Raschner et al., 2008). The test

device fulfills reliability and validity criteria (Baierle, Kromer, Petermann, Magosch, & Luomajoki, 2013; Wojtyczek, Pashawska, & Raschner, 2014; Patel, Shende, & Khatri, 2013) and age and sex-related norms were generated from the data of children and adults (Raschner et al., 2008).

#### **2.4.2. Body Composition/Bioelectrical Impedance Analyses (BIA)**

Bioelectrical impedance analysis (BIA) is a non-invasive measurement for estimating body composition. It acquires the resistance of body tissues to the applied electric current. In comparison to fat, muscles or extracellular mass of the body that are composed mostly of water are good electrical conductors. As a result BIA measures total body water (TBW), body fat (BF) and the fat free body mass (FFM) (Tomczak, 2003). Body composition was measured using the device BIA 101 manufactured by Akern Srl (Via Lisbon, Italy). Talma et al. reported strong evidence for a good reliability ( $r \geq 0.82$ ) of the use of BIA in children. Although test-retest mean differences and validity testing showed unsatisfactory heterogeneous data, probably due to the use of different devices, BIA is considered as a practical and child friendly method to estimate body composition (Talma, Chinapaw, Bakker, HiraSing, Terwee, & Altenburg, 2013).

#### **2.4.3. Leg Strength**

Maximal isometric leg strength was measured in a seated position using the leg trainer GENIUS-ECO manufactured by FREI Aktive Reha-Systeme (Kirchzarten, Germany). Leg strength is measured in Newton (N). Generally the reliability and validity of isometric strength measurements are evaluated as high (Abernethy, Wilson, & Logan, 1995; Verdijk, Van Loon, Meijer, & Savelberg, 2009).

#### **2.4.4. Mental Health Problems**

Participants' mental health status and behavioral problems were measured using the Strength and Difficulties Questionnaire (SDQ, Goodman, 1997). The SDQ assesses mental health problems of children aged 4 to 16. Parents are asked to indicate whether each of 25 attributes applies to their child. Each item is rated on a three-point Likert scale (0 = not true, 1 = somewhat true, 2 = certainly true). It covers psychological difficulties and strengths in five subscales: emotional problems (e.g. worries and anxieties), hyperactivity (e.g. restlessness and easy to distract), conduct problems (e.g. lies, temper problems), peer problems (e.g. very popular or being a loner) and a prosocial scale (e.g. being considerate) (Goodman, 1997). The scores of the subscales emotional symptoms, hyperactivity, conduct problems and peer problems can be summed to generate a total difficulties score ranging from 0 to 40. Authors provide cut-off scores to classify individual scores as "normal" (0 - 13), "borderline" (14 - 16) or "abnormal" (17 - 40). Normative data for a German sample is available (Woerner, Becker, Friedrich, Klasen, Goodman, & Rothenberger, 2002). The reliability for the subscales varies between  $\alpha = .59$  and  $\alpha = .78$ . The reliability for the total difficulties sum score was high, with Cronbach's  $\alpha = .83$  (Achenbach et al., 2008). Empirical support for a sufficient validity was given by correlations between .72 and .75

with the Child-Behavior-Checklist (CBCL, [Woerner et al., 2002](#)).

#### **2.4.5. Health-Related Quality of Life**

The subjective feeling of health and well-being was assessed with the KID-SCREEN-10 ([Ravens-Sieberer et al., 2010](#)). The questionnaire was developed to measure health related quality of life in children aged between 8 to 18 years. The instrument can be used in healthy and ill children as well as via self- and parent-report. 10 items cover the domains: general health (e.g. “Have you felt fit and well?”), emotions (e.g. “Have you felt sad?”), school (e.g. “Have you got on well at school?”), freetime (e.g. “Have you been able to do things that you want in your free time?”) and friends (e.g. “Have you had fun with your friends?”). Higher values indicate better health-related quality of life. The sum score can be transformed into a t-value with a mean of 50 and a standard deviation of 10. The authors report a Cronbach’s  $\alpha = .82$  for the self-report. Validity is also reported as being acceptable ([Ravens-Sieberer et al., 2010](#)).

### **2.5. Data Analysis**

Means were compared in a one-factorial repeated-measures ANOVA using time (pre, after six month, post) as the main factor. Post-hoc tests included a pairwise comparison between the three points of assessment. Effect sizes were computed by using Hedges’  $g$ , which is an alternative to Cohen’s  $d$  and corrects for biases due to small sample sizes, and its 95% confidence interval ([Rosenthal, 1994](#)). Effect sizes were defined using Cohen’s guidelines in which 0.2 represents a small effect, 0.5 a moderate effect and 0.8 a large effect ([Cohen, 1977](#)).

Comparison of variables between the dropouts and participants was analyzed using nonparametric tests (chi-square) for categorical variables and t-tests for continuous variables. The significance level was set at  $p < .05$ , trend levels up to  $p < 0.1$  will be reported. All analyses were conducted using SPSS Statistics (version 18.0). The sample size varies due to missing data.

## **3. Results**

### **3.1. Patient Sample and Demographic Data**

12 out of 41 originally participating children dropped-out prior to or during the intervention phase. Three other participants who attended less than 14 judo practices were excluded from analyses. 26 children (age 7 - 14,  $M = 10.55$ ,  $SD = 1.94$ ), 15 boys and 11 girls, completed on average 28 judo practices (range 14 - 39,  $SD = 6.18$ ) and were included in the following analyses. Four children were categorized as overweight and 22 as obese, average BMI was 26.92 (range 19.7 - 34.6,  $SD = 3.92$ ).

### **3.2. Dropout-Analysis**

A comparison between dropouts and participants showed that dropouts in tendency showed a higher weight  $t(38) = 1.91$ ,  $p = .063$ , lower scores in stability (f/b)  $t(37) = -1.75$ ,  $p = .088$  as well as a significantly higher BMI  $t(38) = 2.47$ ,

$p = .018$  and higher scores in the subscale peer problems of the SDQ  $t(36) = -3.12, p = .004$ .

### 3.3. Physical Data

Baseline and 6- and 12-month results are reported in **Table 1**. ANOVA yields a significant change between pre and post measures in stability r/l  $p < .001$  and stability f/b  $p < .001$ . There is also a significant increase in fat free mass ( $p = .004$ ), leg strength right ( $p = .019$ ) (**Figure 1**) and leg strength left ( $p = .022$ ).

Changes in stability showed a significant average difference between baseline and 6 months later (f/b  $p < .001$ , r/l  $p < .001$ ) as well as between baseline and 12 months later (f/b  $p < .001$ , r/l  $p < .001$ ). There was no significant difference between fat free mass at baseline and 6 months later but between baseline and after completion of the training ( $p = .009$ ). Similar results were found regarding leg strength with no significant differences between baseline and 6 months but a significant difference between baseline and 12 months after the intervention started (leg strength left  $p = .049$ , right  $p = 0.46$ ). Influence on physical performance is also illustrated by moderate to large effect sizes (**Table 2**).

**Table 1.** Results for the outcome measures (ANOVA and post-hoc test).

Outcome Measure	Baseline	after 6 months	after 12 months	ANOVA		6 months difference		12 months difference	
	M (SD) (n = 24 - 26)	M (SD) (n = 20 - 26)	M (SD) (n = 22)	F	p Value	Average diff. t1-t2 (SE)	p Value	Average diff. t1-t3 (SE)	p Value
FM	37.19 (7.18)	34.85 (8.9)	32.89 (7.29)	2.16	.130	2.57 (1.34)	.211	3.03 (1.84)	.349
FFM	32.59 (4.57)	35.16 (5.95)	40.07 (9.4)	8.85	.001	-1.92 (0.93)	.163	-7.04 (2.07)	.009
Stability r/l	7.53 (1.52)	5.29 (0.55)	5.26 (0.54)	36.88	<.001	2.24 (0.34)	<.001	2.28 (0.37)	<.001
Stability f/b	7.59 (1.54)	5.55 (0.56)	5.02 (0.86)	33.96	<.001	2.09 (0.38)	<.001	2.69 (0.41)	<.001
Leg strength left	923.39 (439.36)	1075.54 (394.23)	1093.43 (291.39)	4.27	.022	-99 (73.70)	.590	-227.06 (85.30)	.049
Leg strength right	909.08 (446.12)	1089.19 (402.33)	1180.52 (484.83)	4.46	.019	-106.06 (82.50)	.647	-250.78 (93.14)	.046
Total difficulties	19.72 (4.48)	12.36 (5.21)	12.14 (8.08)	13.44	<.001	3.45 (0.54)	<.001	7.05 (1.29)	<.001
Emotional problems	4.24 (2.22)	2.59 (1.37)	3.68 (2.78)	1.76	.187	0.55 (0.46)	.242	0.75 (0.35)	.044
Conduct problems	4.16 (1.7)	2.83 (1.75)	2.18 (1.94)	10.45	<.001	1 (0.38)	.017	1.85 (0.39)	<.001
Hyperactivity	4.56 (2)	3.87 (2.28)	3.55 (2.7)	1.68	.200	0.65 (0.53)	.230	1 (0.50)	.059
Peer problems	5.8 (1.12)	2.91 (2.35)	2.73 (2.6)	33.15	<.001	3 (0.48)	<.001	3.45 (0.54)	<.001
Prosocial Score	8.16 (1.8)	7.78 (1.59)	8.18 (2.06)	1.74	.188	0.50 (0.30)	.116	-0.05 (0.34)	.883
HrQoL	47.47 (8.54)	45.05 (5.92)	48.34 (8.93)	3.19	.055	-0.52 (1.64)	.754	-4.61 (2.40)	.072

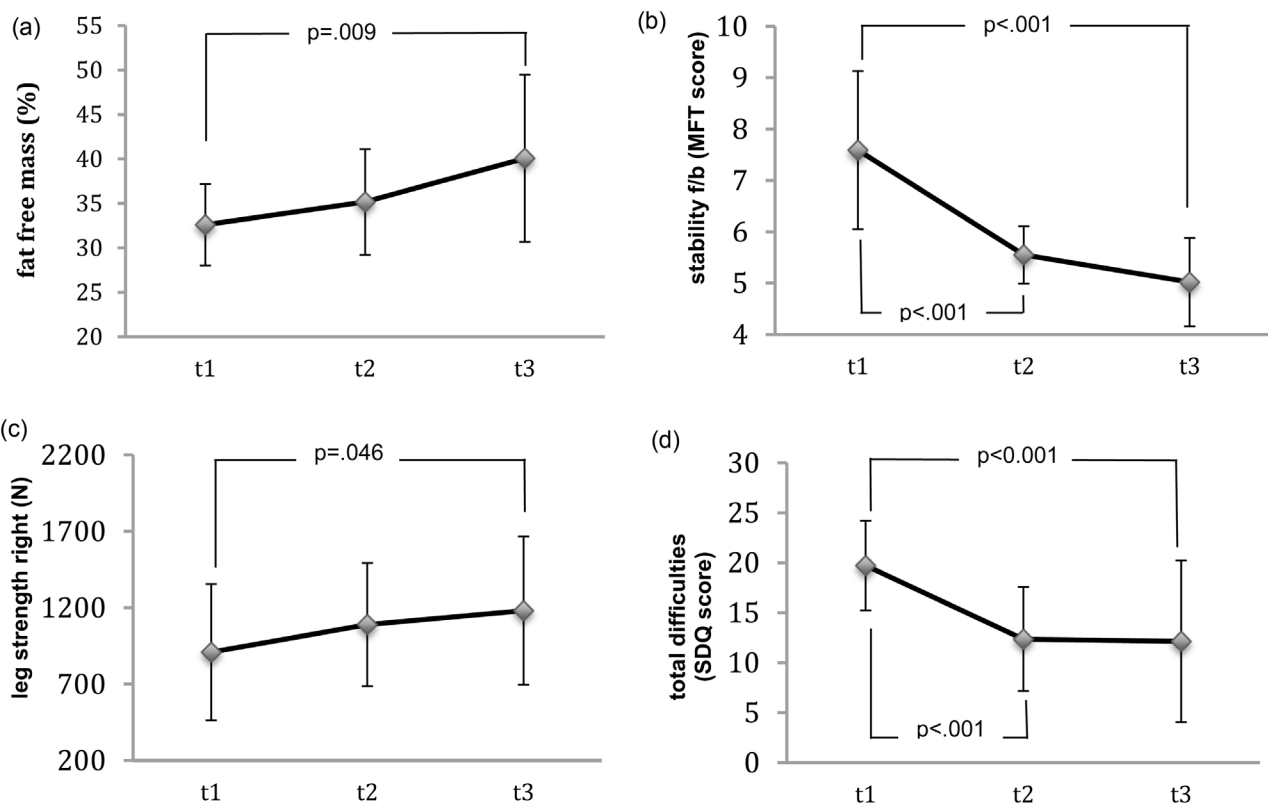
Note. FM = fat mass, FFM = fat free mass, HrQoL = Health related Quality of Life, M = mean, SD = standard deviation, SE = standard error, t1 = baseline, t2 = after 6 months, t3 = after 12 months.



**Table 2.** Effect sizes of differences after 6 and 12 months.

	after 6 months		after 12 months	
	Hedges' g	95%-CI	Hedges' g	95%-CI
FM	-0.29	-0.84; -0.26	-0.6	-1.18; -0.02
FFM	0.49	-0.07; 1.04	1.04	0.44; 1.65
Stability r/l	-1.96	-2.26; -1.3	-1.99	-2.66; -1.33
Stability f/b	-1.76	-2.40; -1.12	-2.02	-2.71; -1.32
Leg strength left	0.37	-0.18; 0.91	0.45	-0.13; 1.02
Leg strength right	0.42	-0.13; 0.97	0.58	0.0; 1.16
Total difficulties	-1.52	-2.16; -0.88	-1.18	-1.8; -0.56
Emotional problems	-0.89	-1.48; -0.3	-0.22	-0.8; 0.35
Conduct problems	-0.77	-1.36; -0.18	-1.09	-1.7; -0.48
Hyperactivity	-0.32	-0.89; 0.25	-0.43	-1.01; 0.15
Peer problems	-1.59	-2.24; -0.94	-1.57	-2.23; -0.92
Prosocial Score	-0.22	-0.79; 0.34	0.01	-0.56; 0.58
HrQoL	-0.32	-0.92; 0.27	0.1	-0.48; 0.679

Note. FM = fat mass, FFM = fat free mass, HrQoL = Health related Quality of Life, M = mean, SD = standard deviation, SE = standard error, CI = confidence interval. Sample size varies between 22 (t3) and 26 (t1).



**Figure 1.** Mean changes in (a) fat free mass, (b) stability front/back, (c) leg strength of right leg, (d) total SDQ difficulties score. Sample size varies between 22 (t3) and 26 (t1). Error bars indicate standard deviation.



### 3.4. Psychosocial Data

A comparison of the psychological variables prior to the intervention and thereafter in tendency shows a change towards a better health-related quality of life  $p = .055$ . Parents also report less conduct problems ( $p < .001$ ), peer problems ( $p < .001$ ) and a lower sum score for total difficulties in the SDQ ( $p < .001$ ) after participating in the intervention (**Figure 1**).

Changes in the SDQ total difficulties showed a significant average difference between baseline and 6 months ( $p = .001$ ) as well as between baseline and 12 months later ( $p < .001$ ). The data on the subscales *conduct problems* and *peer problems* show equal results. Effect sizes for the SDQ total scale and emotional and peer problems were large already for t2 and for t3 (**Table 2**).

## 4. Discussion

The primary purpose of this pilot work was to test the acceptability and suitability of judo as an intervention for obese children. Due to the lack of a control group a statement to what extent the results are influenced by time and maturation is not possible, but must be considered when interpreting the data. The study indicates that obese children participating in a judo exercise intervention show significant improvements in postural stability, leg strength and mental health. There is also a positive trend in health-related quality of life.

One major difficulty of studies treating childhood obesity is a high dropout rate. In our sample 30% ( $n = 12$ ) of those who registered for the study withdrew prior to or during the intervention. Other studies showed similar rates, for example Böhler et al. (Böhler, Bengel, Goldapp, & Mann, 2012) reported a dropout rate of 32%. Essential for a successful attendance seems to be a sufficient motivation and commitment of the parents, who regularly accompany and support their children throughout the intervention phase. This assumption fits to the results of Froiland (2011), who reports an attrition rate of 0%. In this study parents were taught to develop an autonomy supportive style and to help their children set intrinsic learning goals. Moreover peers spread motivation for physical activity and could when included in the study lower the attrition rate (Froiland & Davison, 2016b).

Furthermore, studies indicate that the risk of dropping out is higher for children with higher weight at the beginning of the study (Skelton & Beech, 2011). This is in line with the present study. Participants dropping out of the study in tendency also had a poorer postural stability, a higher weight and BMI. Another difference between dropouts and those completing the study was found in the subscale *peer problems* of the SDQ. Dropouts showed lower scores indicating fewer problems with their peers. Probably, children who have fewer problems with their peers are in tendency more introverted and thus shy and reserved in peer interaction. This might be a barrier to engage in a group intervention and a reason why they were more likely to drop out. Another reason might be that they already have a stable social network and thus were not interested in making new contacts at the judo practice.

22 of all participating children were classified as obese and extremely obese. Obviously, predominantly families with obese children showed interest in entering the exercise intervention. This suggests a connection between higher weight and higher psychological stress, awareness of the weight problem, the necessity to make a change and motivation to enroll for an intervention study. Analyzing the baseline values all participants showed values below average in stability and leg strength, thus showing a poor physical fitness indicating a high level of inactivity. Statistically significant improvements in postural stability and leg strength were observed after 6 months of judo training. A good postural stability leads to greater safety in unexpected situations and a lower risk to fall. Those results reflect the positive effects of the training since judo as sports focuses on stability and supports sturdy leg and torso muscles.

However, it must be assumed that parts of the gain in strength might be due to age-related physical development. Nevertheless the observed improvements in balance and stability seem to exceed possible effects of time. A detection of age-related maturation processes by means of a control group is a crucial point for further studies. However another solid marker for the positive impact of the judo training on the physical condition was found in the increase of fat free mass and a moderate effect in the decrease of fat mass.

The data on mental health emphasize the psychological distress and a strong need for psychological support: 77% of the participants were classified as *abnormal* and 15% as *borderline* at baseline. Only 8% were categorized as *normal* considering their behavioral problems rated by their parents. Within the German Health Interview and Examination Survey for Children and Adolescents 7.2% children were classified as *abnormal* and 7.5% as *borderline* (Hölling, Erhart, Ravens-Sieberer, & Schlack, 2007). Another epidemiological study performed by Böhler et al. (Böhler et al., 2012) on obese children found an increased prevalence in this sample. 28.7% of the analyzed participants showed *abnormal* behavior and another 15.3% were classified as *borderline*. However both reported studies are prospective cohort studies with a larger pool of participants and are as a result not comparable to our intervention study. In this study an exercise intervention was offered to obese children and participation was on a voluntary basis. Roth and colleagues pointed out that obese children who register for a treatment represent a group of highly stressed patients and that obese children that do not participate in clinical studies only show a slightly higher prevalence of mental health problems compared to their normal weight peers (Roth et al., 2008).

Since self-discipline and the acquisition of social skills are important elements of judo positive effects on behavioral problems and psychological well-being might be ascribed to the weekly practice. Furthermore exercising in groups with peers could probably enhance social contacts and thereby counteract social isolation. Evidence for this assumption is provided by the changes in the total difficulties score of the SDQ as well as in the subscales *conduct problems* and *peer problems*. The significant positive changes in these subscales suggest that more parents were able to describe their children positive regarding their behavior af-

ter completion of judo training and rated them to be in better contact with peers and to be less angry and defiant.

The positive effect on the physical abilities can be explained by maturation and growth. Due to a missing of a control group we cannot attribute the results to the judo training. However the improvements in mental health and behavioral problems seem to exceed maturation process. These can be ascribed to the new experiences and new social contacts on the one hand with other obese children and on the other hand with being physically active. The results support the importance of lifestyle interventions in the treatment of childhood obesity. Large effect sizes on both physical and psychological data suggest the clinical importance. Already after 6 month large effects were detected on postural stability, the total difficulties score of the SDQ and in the subscales *peer problems* and *emotional problems*. Effects on fat mass, fat free mass, leg strength, *conduct* and *emotional problems* showed an increase already at t2 and were greater when the duration of treatment was longer than six month at t3.

The study was designed as a pilot study and does not provide a control group. Therefore we are not able to determine changes that would have occurred without partaking in the intervention due to maturation processes and time effect. Furthermore effect sizes might be positively biased due to the small sample.

Another limitation is that the judo practice indeed was similar in the three different groups with an equal training structure but it was not standardized. In future studies we would recommend a more standardized structure and a comparative approach giving specific instructions to the trainer regarding the special needs of overweight and obese children. Furthermore, more homogenous age groups would increase the practicability during training, as roughly same sized and weighted children are needed for partner exercises.

Since there are no follow-up data on how many children are physically active beyond the study period statements about long-term effects and changes in lifestyle are not possible.

## 5. Conclusion

We observed significant changes in physical fitness and psychological well-being in obese children after participation in a one year judo practice. Participants had the opportunity to exercise in homogeneous weight groups in order to reduce possible fears or shame and to overcome existing barriers. Judo provides a good possibility to engage in sports for obese children because participants benefit from a higher body weight and therefore are more motivated and less frustrated when starting to get physically active. Given the fact that physical activity among children and adolescents in their daily life decreases, approaches to support obese children in developing a more active lifestyle resulting in a higher health-related quality of life and physical fitness are of great significance.

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### Conflict of Interests

The authors declare that there are no conflicts of interest.

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## Abbreviations

BF	Body fat
BIA	Bioelectrical impedance analyses
BMI	Body-Mass-Index
CBCL	Child-Behavior-Checklist
FFM	Fat free mass
f/b	Front/back
HrQoL	Health related quality of life
M	Mean
r/l	Right/left
SD	Standard deviation
SE	Standard error
SDQ	Strength and Difficulties Questionnaire
TBW	Total body water



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