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| **BMI and Physical Fitness in Adolescents in the FMS Study** |
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**ABSTRACT**

**Background:** Overweight and obesity have become growing public health issues. Since being overweight and obese are likely to be continued into adulthood, it is crucial to stop the increasing prevalence among children and adolescents.

**Purpose:** To do a relative validity and conduct a test-retest reliability study on the "**F**ysisk kraft, **M**ental harmoni och **S**ocial kapacitet (FMS)" (Physical power, Mental harmony and Social capacity) questionnaire as well as to analyze the correlation between BMI and physical fitness.

**Method:** As part of the FMS student profile assessment, 3692 (2173 boys and 1519 girls) 16 to 18 years old students from 45 schools all around Sweden participated in this study. Height and weight was collected to calculate BMI. Physical fitness tests which measure cardiorespiratory fitness, muscular strength and flexibility were carried out by the participants. Relative validity on three variables (diet, tobacco and alcohol) as well as a test-retest study was also conducted on 18 (11 boys and 7 girls) 16 years old students from a school in Eslöv, which was not part of the initial study. All participants in the test-retest study took part in the tests which measure muscular strength and flexibility with one-week interval.

**Results:** A weak inverse relationship between BMI and physical fitness was found among the 16 to 18 years adolescents in this study, r= -0.06 to -0.07 (*P*<0.05) for flexibility, r= -0.13 to 0.10 (*P*<0.001) for strength, r= -0.14 to -0.33 (*P*<0.001) for cardiorespiratory fitness and r= -0.15 to -0.27 (*P*<0.001) for overall fitness. The correlation was stronger in overweight/obese individuals compared to normal weight individuals. The test-retest study revealed that the FMS questionnaire is a reliable tool. The test-retest analysis showed almost perfect test-retest reliability for strength, flexibility and balance, moderate to perfect agreement for questions regarding lifestyle and substantial to almost perfect agreement for questions concerning psychological health, somatic pain, school environment and relationships. Relative validity was also found for the questionnaire related to questions regarding diet, alcohol and tobacco.

**Conclusion:** Physical fitness and BMI was weakly negatively associated. Overweight and obese individuals scored lower in the fitness tests compared to their normal weight counterparts. The FMS is a reliable tool with relative validity. In order to combat the increasing prevalence of overweight and obesity among adolescents, the promotion of physical activity in school settings has to be improved. Walking to and from school, increasing physical education time and food and nutritional education are a few suggestions.

**1 Introduction**

**1.1 Physical Fitness & Health**

Physical inactivity and poor physical fitness (PF) in children and adolescents are growing public health problems globally. Simultaneously, overweight and obesity trends are spiking. Physical fitness has been defined as “a set of attributes one has or achieves that relates to the ability to perform physical activity (PA)”. There are various components that contribute to one’s PF. The health-related components include body composition (frequently expressed as body mass index, kg/m2), aerobic fitness (also known as cardiorespiratory fitness), muscular strength and endurance and flexibility (1).

Although PA and PF are often used interchangeably, they are not the same. However, both provide beneficial health outcomes and they are related. Gender, age, genetics and health status are all determinants of physical fitness. However, the main controllable and modifiable determinant is physical activity habits and/or pattern (2). Cardiorespiratory fitness (CRF) is commonly used to measure habitual physical activity. It is defined as the ability of the circulatory and respiratory system to supply oxygen to the working muscles during sustained exercise. CRF, which is generally quantified as maximal oxygen uptake (VO2 max), is a reliable and low-cost measure which not only measures habitual PA, but it is also a valuable indicator of health (3). Furthermore, CRF is considered to be an essential health marker and predictor of all cause-mortality and morbidity (4). Muscular strength is also an essential part of PF which is when a muscle or a muscle group, in one single contraction, generates the maximum force (5). Muscular strength has been shown to provide health benefits, not only for adults, but for youths as well. Evidence suggests that strength training (ST) may aid in weight loss and weight control through which the resting metabolic rate increases as result of it. ST may also improve bone mineralization, which in turn can prevent injuries from sports. Although peak bone mass is mainly influenced by genetics, increased bone mineral density resulting from ST is also necessary for young girls who are at increased risk of developing osteopenia and/or osteoporosis (6). Moreover, ST has also been shown to decrease the risk of developing insulin resistance independently of one’s CRF among youngsters. The risk reduction was observed in both moderate to high muscular strength as a result of ST compared to low muscular strength (7). One’s flexibility, which is also included as a component in PF, may enhance through stretching exercises. It is believed that inflexibility or hyper flexibility may increase the risk of injury while performing sports (8). In other words, moderate flexibility is preferable. In addition, studies have reported that stretching before and/or after exercise does not decrease the onset of muscle soreness which usually occurs the day after (9). Engaging in habitual physical activity, including cardio, strength and flexibility training, early in adolescence is therefore important for achieving a good physical fitness which may even possibly halt the increasing trends in overweight and obesity among adolescents worldwide.

Research suggests that physical fitness is linked to body mass index (BMI). Studies have shown that overweight/obese children and adolescents are more likely to have a lower physical fitness compared to normal weight individuals (10-16). Although BMI does not distinguish between fat and muscle mass, nor does it show where the fat is distributed on the body, evidence yet support the notion that normal weight children and teenagers are more probable to have a higher PF than overweight/obese individuals (10-16). However, studies analyzing the correlation between BMI and physical fitness have primarily only included cardiovascular fitness tests such as running tests. While a correlation between CRF and BMI has been found, it does not provide a complete view of adolescents’ physical fitness.

**1.2 Aim**

Therefore, the aim of this study was: (a) to do a relative validation of three of the variables included in the questionnaire as well as conducting a test-retest reliability of the complete questionnaire; (b) to analyze the correlation between BMI and the three physical fitness components, including overall fitness. Moreover, it was hypothesized that normal weight adolescents would have higher physical fitness compared to overweight/obese individuals.

**1.3 Physical power, Mental harmony and Social capacity (FMS) background**

"**F**ysisk kraft, **M**ental harmoni och **S**ocial kapacitet (FMS)" (Physical power, Mental harmony and Social capacity) student profile is a designed tool conducted by the Swedish Institute Physical Mental Social (FMS) AB for adolescents between the ages of 12 and 19 years old. The definition of FMS originates from the World Health Organization (WHO)’s definition of health: "a state of complete physical, mental and social well-being, and not merely the absence of disease or infirmity" (17)

FMS student profile assesses teenagers’ physical, mental and social health. The data was collected between 2004 and 2013 on 30 000 profiles in 60 schools all around Sweden. (17) The questions included in the questionnaire are mostly based on Sture Malmgren and Gunnar Andersson’s "Hälsoprofilbedömning", HPB (Health Profile Assessment). Some of the questions are even identical or similar to the questions in HPB. Between 1968 and 1978, HPB was developed and tested within a health care program on employees from Saab-Scania, on subjects from a health information campaign and randomly selected subjects from the city of Linköping in Sweden. The purpose of developing an assessment method as such was to enable individuals to take part of their own information associated to the person’s lifestyle, health and wellbeing (18).

The FMS include three parts:

* self-assessment of health habits and health experience
* physiological test; a maximal test (Cooper Test) or a submaximal work test on a bicycle ergometer, 1MileWalk test and/or Step test as well as perceived exertion (Borg Scale), muscular fitness and flexibility tests
* discussion

The FMS student profile assessment starts with skeletal and anthropometric measurements. Muscular fitness tests such as the sitting chair (90 degrees), belly back, arm press and sit-ups, a balance test (Flamingo test) and flexibility tests are thereafter carried out on the subjects (19). Thereafter the participant has a conversation with an instructor based on the questionnaire. Subsequently, a KASAM test is used. KASAM,”Känslan av sammanhang” or Sence of Coherence (SOC) concept was developed by Dr. Aaron Antonovsky in 1987. Antonovsky, who was a professor in medical sociology, proposed that a person who has a clear understanding of the world experiences feelings of comprehensibility, manageability and meaningfulness. Antonovsky claimed that individuals with these characteristics are better at coping and managing stress, thereby remaining healthy (20). Research suggests that students with strong SOC are less prone to school-related stress compared to students with low SOC. In addition, students with high SOC perceive education and learning as meaningful (21). Therefore, by using the KASAM questionnaire in school settings may help to seek these factors and improve SOC among students.

**1.4 FMS Questionnaire**

The different variables that assess physical, mental and social health which are included in the FMS questionnaire are given below.

Leisure activities

Time spent on leisure activities gives an estimate on an individual’s activity level, energy level and participation in social activities (18). Examples of leisure activities included in the FMS questionnaire are hobbies, friends, sports, reading etc.

Perceived stress

Stress in terms of feelings of pressure caused by a disagreement between desires and opportunities in the environment as well as between one’s perceived reality and expectations affect one’s health and well-being (18). Stress among students is common due to the amount of workload, but also the pressure to perform and attain good grades (22). In the questionnaire however, the former stress question has been renamed into life tempo. This was due to wanting to make the student aware of how stress and feelings of calmness affect one’s life in general. However, stress is specifically brought up again, towards the end of the questionnaire, but only concerning stress during the school day. The question about life tempo is subdivided into the frequency of being ‘pressured and shattered’ and ‘calm and gathered’ at school and/or during leisure time.

Physical activity

Physical activity in this context refers to training or activities aimed at improving and/or maintaining physical condition and/or health. Adolescents benefit from regular PA by developing healthy heart and lungs, bones, muscles and joints, coordination and movement control as well as maintaining body weight. Regular PA is also linked to reduced risk of anxiety and depression. Likewise, PA can aid in the social development of adolescents by allowing for social communication, self-expression and building self-confidence. Furthermore, physically active teenagers are more likely to avoid the use of alcohol, tobacco and drugs as well as performing better at school (23). In the questionnaire, the question is asking about the frequency of PA. It is subdivided into a minimum of 20 minutes of planned ‘physical conditioning enhancing exercise’, which involves at least 12 (moderate intensity level) on the Borg scale of perceived exertion, and ‘daily exercise of 60 minutes which requires energy expenditure’. The latter includes both physical conditioning enhancing exercise and, for example, walking, skateboarding, gardening and school sports.

Perceived health

Self-perceived health not only measures an individual’s physical and mental health, but it can also reveal a person’s health behaviors, social well-being, socio-economic status and quality of life. These aspects, along with symptoms of chronic fatigue and pain, may not always be obvious to the external examiners which all effect how an individual perceive his/her own health (24). Moreover, it is also well recognized in studies that self-perceived health is a predictor of mortality (25). The question in FMS is referring to both psychological and physical well-being. A teenager can perceive his or her general well-being as “bad” due to various reasons such as having pimples, not having a girl/boyfriend, being too fat or too thin and complexes. The question is subdivided into; ‘general well-being’ referring to perceived health, ‘symptoms of pain in neck, shoulder and back’, ‘headaches and/or stomach pain’ and ‘perceived fatigue’.

Tobacco use

The harmful effects of smoking are well documented in the literature. It can cause cancer, heart and lung diseases and lead to premature death. Although the evidence for the damaging effects of snuff are scarce, in addition to being claimed as less harmful than smoking, it has been shown that snuff users has an increased risk of developing pancreatic cancer (26) Yet, adolescents are tempted to try tobacco and many even develop an addiction by the age of 18. According to previous surveys such as the Health Behavior of School-aged Children (HBSC) (WHO collaboration) conducted in Sweden and in other European countries, tobacco use has shown to be linked to other health issues and risk factors in teenagers. These include unhealthy eating habits, increased levels of alcohol consumption, poor self-perceived health and even bullying and early sexual activity (27). In FMS, everything except “never smoked” or “never snuffed” has been approved as a health factor. This means that adolescents that smoke or use snuff only “occasionally at parties” have tobacco use as a risk factor. The numbers of cigarettes have been quantified per day, whereas the number of snuffboxes used per week was recorded.

Alcohol

Trends of alcohol use among teenagers in Sweden show that most adolescents nowadays consume less alcohol. However, those who do use alcohol frequently drink enormous amounts (28). Although alcoholic beverages have long been a part of social gatherings, excessive long-term alcohol consumption is associated with addiction (29). Extensive long-term use of alcohol which turns into alcoholism is also related to both mental and somatic disorders/illnesses (18). Frequency of alcohol consumed per month, as well as “rarely” and “never drink” was used in the questionnaire.

Diet

Dietary habits are developed during adolescence and they are likely to continue into adulthood (30). An irregular eating pattern, particularly skipping breakfast, has been linked to overweight and obesity among adolescents. Unhealthy snack foods and drinks high in sugar and fat are commonly consumed instead between meals due to irregular meal patterns, even more so for breakfast skippers (31-32). In the questionnaire, the question about diet has been subdivided into frequency of ‘regular healthy eating habits’ and ‘intakes of candy, soda, crisp, cookies, etc.’. FMS herein define regular healthy eating habits as consuming breakfast, lunch, dinner and snack (sandwich or fruit, for example) every day. These meals ought to include sufficient amounts of carbohydrates (pasta, potatoes, rice, bread, and nuts), protein (chicken, meat, fish, beans and lentils) vitamins and minerals (fruits and vegetables). In addition, intakes of these nutrients should not be over-or under consumed. Intakes of candy, soda, crisp, cookies, etc. have been defined as risk intakes.

Sleep

Sleep and its duration, quality and timing are vital to health. Sleep is an important influencing factor of adolescents’ quality of life while at school as well as during their spare time. Adolescents need eight to nine hours of sleep. However, unfortunately, many teenagers nowadays do not get enough which has its consequences. Lack of sleep and low quality of sleep can lead to reduced appetite for breakfast, affect learning abilities, lead to distractibility, inattention, irritability, reduced motivation and even eventually mental ill-health (33). Moreover, evidence shows that adolescents sleeping less than six hours on weeknights have an increased risk of depression and poor academic performance (34). In the FMS questionnaire, the question is subdivided into; ‘sleep onset time’, ‘numbers of sleeping hours’ and ‘quality of sleep’.

Peer and Adult Relationships

Parental relationships during adolescence are of outermost importance. However, research has demonstrated the influential role of non-parental adult and/or mentor relationships (VIPs) in adolescents’ social and emotional health as well as academic performance. VIP’s have reported to have a contributing role in a youth’s self-esteem, problem behavior and depressive symptoms (35). Peer relationships among youths are certainly as important as both parental and VIP’s relationships. Sometimes even more important if they start to outdo parents as adolescents’ main social support and influential factor. Adolescents’ that have peer relationships have shown to thrive more in school compared to those with insecure peer relationships. Furthermore, skipping school has been reported to be more common among adolescent girls with more unstable peer relationships (36).

Screen and Media Time

Sedentary screen and media activities (TV viewing, video games, computer games and internet surfing) have in recent decades replaced leisure-time physical activity among adolescents. Evidence have demonstrated that interactive media such as video games and internet surfing are correlated to greater BMI and body fat percentage. Female high-school students (n = 194), aged 14 to 17 years old, in the “high” (> 4 hours/day) interactive media group compared to the “low” (< 2.5 hours/day) had higher BMI and percentage of body fat, after adjusting for physical activity level and fitness (37). It has also been suggested that screen and media time are linked to higher food consumption, in terms of energy-dense foods and drinks, among adolescents. High-school boys and girls (n = 2202), aged 12.5 and 17.5 years old reporting to spend more than 4 hours/day on video games, TV watching, using computers or using the Internet for recreation during weekdays and weeknights were more likely to drink additional sweetened beverages and eat savory snacks and less likely to consume fruits in comparison to those spending less than two hours per day (38).

**2 MATERIALS & METHOD**

**2.1 Study design and participants**

This cross-sectional study analyzed data from a sample of Swedish adolescents. The data, which was a part of the FMS student profile assessment, was collected during 2004 until 2013 from 45 schools in cities all around Sweden. The initial number of 16 to 18 years old that filled in the questionnaire was 19660 youngsters. All adolescents with valid data for gender, age, height and weight were included in the final sample. Subjects with no data from the cardiorespiratory fitness, muscular strength and endurance or flexibility tests were excluded from the study as well as participants who were considered being underweight, according to BMI. The final sample was therefore composed of 3692 subjects (2173 boys, 59% and 1519 girls, 41%).

**2.2 Reliability study**

In the test-retest reliability study, 18 participants aged 16 years old (11 boys and 7 girls) from a school named Norrevångsskolan in Eslöv were asked to fill in the questionnaire and complete the fitness tests with one week interval. Only the fitness tests for muscular strength and endurance as well as for flexibility were completed and not for cardiorespiratory fitness. Since there is abundant validation studies of the tests used for measuring CRF, it was not necessary to be included in the reliability study.

**2.3 Ethics**

Parents/guardians and the participants were all informed about the nature and the procedure of the FMS questionnaire and the fitness tests. Signed consent forms by the parents/guardians and the students’ agreement to participate was included.

**2.4 Anthropometric measurements**

The anthropometric measurements were conducted by school nurses and all subjects were barefoot, however, they were not in their underwear. A Seca scale (range, 0.05 to 300 kg; precision, 0.05 kg) was used to measure the weight and a stadiometer combined into the Seca tool (range, 30 to 220 cm; precision, 1 mm) was used to measure the height in the Frankfort horizontal plane.

**2.5 Fitness test measurements**

All the fitness tests took place during physical education (PE) sessions conducted by PE teachers according to standardized protocols. PE teachers had been provided with detailed information and demonstrations of the fitness tests prior to testing. The maximal oxygen uptake (VO2 max) was measured through the Cooper Test. The Cooper Test includes warm-up and then running in a steady pace 2.4 km, 3 km or 3.4 km depending on how well trained they perceived themselves. The weight in kilograms of each participant, pulse and the time they finished was recorded and VO2 max calculated. The Cooper test has been validated elsewhere (39) and its correlation factor to a laboratory test (treadmill) is extremely high, 0.897. For students not exercising regularly, however, results obtained from so-called maximal test can be misleading since they may not push themselves to the maximum. Therefore, submaximal tests such as 1MileWalktest, Step test or Åstrand cycle ergometer test were used instead to measure VO2 max. The 1MileWalktest’s distance is 1609 meters and the participants are instructed to walk as fast as possible without running or jogging. The test has been validated previously (40) against walking on a treadmill and the correlation factor was 0.84. The Step test, which has been validated (41-42), involves stepping up and down a 40 cm or 33 cm bench, depending on how well trained one is, for five minutes at a rate of 90 steps per minute. The heart rate is measured from 15 to 30 seconds after completing the test. The Borg Scale is used every now and then during the test and following completion of the test, it ought to land at 12, otherwise the results obtained is not reliable and cannot be used. In the cycle ergometer test, the resistance is set and the rate is defined. Heart rate is measured every minute and the Borg scale is used here as well. The test has also been validated previously (43) and the obtained correlation factor was 0.76. From these tests, depending on which one that was employed, the VO2 max is calculated. Whether or not a person has a high or a low VO2 max is based on ranges found in Supplementary data 1 (table S1).

To measure muscular strength and endurance, a metronome was used in order to standardize the pace of the movements in each strength tests. Sit-ups, arm lift (5 kg for girls, 5 or 10 kg for boys), sitting chair for as long as possible and the belly back test (back extensions/lift) were the strengths test included. An overall strength index from 1 (very weak) to 5 (very strong) was thereafter calculated from the average of the four tests which can be found in Supplementary data 1 (table S2)

The flexibility tests were carried out following warm-up. Shoulder, neck, back, chest and pelvis stretches were included. Again, the average of those four gave an overall flexibility index/score from 1 to 5 which can be found in Supplementary data 1 (table S3).

The balance test, which was not carried out on this sample but yet a part of the FMS questionnaire, takes place on a balance board (3 cm wide, 5 cm high). The students were instructed to balance one foot for one minute and if the foot touched the board, the number of time was recorded. Shoes with sturdy soles were used to standardize the test.

**2.6 Statistical and data analysis**

Statistical analyses were performed using IBM SPSS Statistics for Windows v.22.0 (SPSS, New York, USA). Data were presented as mean and standard deviation and the average weight and height in all age groups were calculated as well. Age- and gender adjusted international cut-off points, according to Cole et al. (2000) and Cole et al. (2007) (44-45), was used to classify the participants as underweight, normal weight, overweight or obese. Because of the small number of obese subjects (136 boys and 65 girls), overweight and obese were combined. Student independent *t*-test was used to test differences in physiological and physical characteristics between normal weight and overweight/obese participants. Significance level was set at α = 0.05. Pearson’s moment correlation coefficient (r) was used to examine the association between physical fitness and BMI in all subjects as well as in normal weight and overweight/obese subjects. Moreover, an overall fitness score from 1 (very weak) to 5 (very strong) was included by calculating the mean from standardized VO2 max values, flexibility and strength scores.

In the reliability study, intraclass correlation coefficient (ICC) with 95% confidence intervals (CI) was used for test-retest. Relative validity was used for three of the variables (tobacco use, alcohol and diet). The results obtained in our study were compared with data from previous surveys which have validated these three particular questions. Therefore, only these three parameters were used and relative validation could therefore only be done for these three variables and not the other questions of the questionnaire. These variables have previously been validated in other surveys such as “Health on Equal Terms” (“Hälsa på Lika Villkor, HLV)” (46) from 2006-2008, which is a National public health survey. “Children and Young in Skåne” (47) (“Barn och Ungas Hälsa”) is another public health survey from 2012 for 6 and 9 graders as well as high school students in grade 2 living in the municipality of Skåne. In order to test if a question is actually measuring what it is intended to, HLV carried out validations studies in the laboratory of SCB. Participants, following filling out the questionnaire, were asked how they perceived the questions and how they were thinking when they responded to the questions. The obtained results from the boys and girls in FMS regarding tobacco use, alcohol and diet were compared to data from Swedish surveys such as HLV and Children and Young in Skåne. Mean weight and height was also calculated from 49 16 years old boys from Bäckängsgymnasiet in order to compare it with the mean weight and height from the 16 years old boys in FMS.

**3 RESULTS**

**3.1 Validity of the FMS Questionnaire**

The data showed that cigarette use was more common than snuffing. The majority of the 16 to 18 years old participants in FMS were non-smokers (66.7% of the boys and 77.2% of the girls) (Supplementary data 2; figure S1), while 75% of the boys and 94% of the girls did not use snuff (Supplementary data 2; figure S2). In other surveys of young people’s tobacco use such as in Health Behaviour of School-aged Children (HBSC) (48), smoking is usually more common among girls, whereas snuffing is more prevalent amongst boys. However, in this case, smoking was more common among the boys than the girls. Snuffing though was in agreement with HBSC where it is predominantly used more among the boys than the girls (46). Compared to the 16 to 19 years old boys and girls in HLV, the number of non-smokers differed. A much higher proportion of the teenagers in HLV were non-smokers, 94% and 90% of the boys and girls, respectively (Supplementary data 2; figure S1). However, the difference in non-snuff users between the two groups was not very large, 85% of the boys and 97% of the girls were non-snuff users (Supplementary data 2; figure S2). Again, even in HLV, snuffing was more common among the boys than the girls (46).

In FMS, the proportion of alcohol consumers was 66.3% and 65.6% in the boys and girls, respectively (Supplementary data 2; figure S3). In contrast, amongst the participants in HLV, the numbers were somewhat higher - 68% in boys and 73% in girls, however the difference was not large (Supplementary data 2; figure S3) (46).

The findings from the FMS showed that the majority of the 16 and 18 years old teenagers always and/or frequently have regular healthy eating habits seven days per week (34.7% and 36.9% of the boys and girls, respectively) (Supplementary data 2; figure S4). In comparison, a higher proportion of the 16 and 18 years old boys in Children and Young in Skåne had regular eating patterns seven days per week (43.5%). While among the girls in Children and Young in Skåne, a smaller proportion had regular eating patterns compared to the girls in FMS. However, those differences are not very large (Supplementary data 2; figure S4) (47).

Tobacco use, alcohol and diet were used because they were the only variables that had fairly similar obtained results in FMS and in HLV and Children and Young in Skåne. Since the results in FMS and the data from the surveys were reasonably similar, it was concluded that there is a relative validity to these three questions.

**3.2 Reliability Test-retest Study**

A total of 18 (11 boys, 7 girls) 16 years old nine graders participated in the test-retest study. The intraclass correlation coefficients (95% CIs) for each fitness tests and each question are presented in table 1. The ICC’s for strength, flexibility and balance were 0.94, 0.96 and 0.89, respectively. This indicates an almost perfect agreement between the two test trials. The ICC’s for the questions regarding lifestyle ranged from 0.75 to 1.00, indicating substantial to perfect agreement except for diet, physical activity and drugs (ICC= 0.56, 0.44 and 0.58, respectively) which had lower ICC’s (table 1). Questions concerning psychological health and somatic pain had ICC’s ranging from 0.64 to 0.88, demonstrating a substantial to almost perfect agreement. The ICC’s for perceived health and stress were however lower (ICC = 0.23 and 0.60, respectively) (table 1). The school environment and relationship questions had ICC’s ranging from 0.61 to 0.95, showing a considerable to almost perfect agreement (table 1).

Table 1: Reliability test-retest with intraclass correlation coefficient (ICC) (95% CIs)

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| Variables | ICC (95% CIs) |
| Strenght | 0.94 (0.84 to 0.98) |
| Flexibility | 0.96 (0.90 to 0.99) |
| Balance | 0.89 (0.71 to 0.96) |
| Leisure activities | 0.82 (0.54 to 0.93) |
| Peer relationship | 0.71 (0.26 to 0.89) |
| Screen & Media time | 0.71 (0.26 to 0.89) |
| Sleep | 0.88 (0.67 to 0.96) |
| Stress | 0.60 (-0.01 to 0.85) |
| Adult relationship | 0. 95 (0.87 to 0.98) |
| Diet | 0.56 (-0.12 to 0.83) |
| Risk intake | 0.93 (0.80 to 0.97) |
| Physical activity | 0.44 (-0.56 to 0. 80) |
| Tobacco | 0.75 (0.35 to 0.91) |
| Alcohol | 1.00 (NO CIs) |
| Drugs | 0.58 (-0.12 to 0.84) |
| Percieved health | 0.23 (-1.10 to 0.72) |
| Body symptoms | 0.64 (0.00 to 0.87) |
| Diffuse symptoms | 0.75 (0.32 to 0.91) |
| School ambition | 0.89 (0.70 to 0.96) |
| School performance | 0.87 (0.66 to 0.95) |
| School thrive | 0.69 (0.19 to 0.88) |
| School support/stimulans | 0.61 (-0.07 to 0.86) |
| Student's own influence on school | 0.70 (0.17 to 0.89) |
| School stress | 0.81 (0.51 to 0.93) |

**3.3 FMS Study**

A total of 3692 subjects (59% boys and 41% girls) with a mean age of 17.5 years old participated in the study. The average weight for boys aged 16, 17 and 18 years old was 71.6 ± 13.3, 73.4 ± 13.6 and 76.2 ± 14.7 kg, respectively. The average height for boys was 178.9 ± 7.0, 179.6 ± 7.1 and 180.4 ± 6.7 cm, respectively in each age group (Supplementary data 3; table S1). While for girls, the average weight for 16, 17 and years old was 60.4 ± 9.6, 61.4 ± 10.0 and 61.5 ± 9.8 kg, respectively. The average height was 166.7 ± 6.4, 166.9 ± 6.3 and 166.7 ± 7.3 cm, respectively in each age group (Supplementary data 3; table S2). Compared to the latest Swedish reference values from 2002 (49), boys in FMS were heavier in terms of weight (65.9, 68.7 and 72.2 kg, respectively in each age group) and height (177.1, 178.7 and 178.7 cm, respectively in each age group) (Supplementary data 3; table S1). Similarly, though not that marked as among the boys, girls in FMS were also heavier with regards to weight only (58.5, 59.0 and 61.3 kg, respectively in each age group). The average height was similar in both groups (Supplementary data 3; table S2). The boys in FMS were also somewhat heavier compared to the Swedish boys in a study by Sjöberg et al. (2012). The average weight for 18 years old boys was 74.4 kg (50), while in FMS the average weight was 76.2 kg (Supplementary data 3; table S3). Likewise, the 16 years old boys in FMS was also heavier in comparison to the 16 years old boys from Bäckängsgymnasiet (71.6 kg and 70.7 kg, respectively) (Supplementary data 3; table S4). Based on international BMI cut-offs for adolescents (44-45), the prevalence of overweight/obesity amongst the boys in FMS were 23.7%, while less amongst the girls - 15.3% (Supplementary data 3; table S5). Descriptive statistics with comparisons of physiological and physical parameters between normal weight and overweight/obese subjects are presented below in table 2 and 3. With regard to the fitness parameters (strength, flexibility and VO2 max), there were significant differences between normal and overweight/obese boys and girls, *P* < 0.001 (except in flexibility among the girls, *P* < 0.05) (table 2 and 3).

Table 2: Physiological and physical characteristics of the girls

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| Physical/physiological | Normal weight | Overweight/Obese |
| characteristics | N = 1275 | N = 244 |
| Age | 17.5 ± 0.3 | 17.5 ± 0.3 |
| Height (cm) | 166.9 ± 6.4 | 166.3 ± 6.8 |
| Weight (kg) | 58.6 ± 6.8 | 75.3 ± 9.3 **‡** |
| BMI (kg/m2) | 21.0 ± 1.9 | 27.2 ± 2.6 **‡** |
| Flexibility | 3.3 ± 1.6 | 3.0 ± 1.5 **\*** |
| Strenght | 3.3 ± 0.9 | 3.0 ± 0.9 **‡** |
| VO2 Max (ml/min/kg) | 37.7 ± 8.2 | 34.8 ± 8.6 **‡** |

**\***= P <0.05, **†**= P <0.01, **‡**= P <0.001

Table 3: Physiological and physical characteristics of the boys

|  |  |  |
| --- | --- | --- |
| Physical/physiological | Normal weight | Overweight/Obese |
| characteristics | N = 1633 | N = 540 |
| Age | 17.5 ± 0.3 | 17.5 ± 0.3 |
| Height (cm) | 179.2 ± 7.2 | 180.0 ± 6.4 **\*** |
| Weight (kg) | 67.8 ± 7.9 | 91.1 ± 13.2 **‡** |
| BMI (kg/m2) | 21.1 ± 1.8 | 28.1 ± 3.4 **‡** |
| Flexibility | 3.1 ± 1.5 | 2.8 ± 1.5 **‡** |
| Strenght | 3.1 ± 0.9 | 2.8 ± 0.8 **‡** |
| VO2 Max (ml/min/kg) | 45.9 ± 9.9 | 38.3 ± 8.8 **‡** |

**\***= P <0.05, **†**= P <0.01, **‡**= P <0.001

**3.4 BMI and Fitness**

The fitness parameters and BMI amongst all the girls were weakly negatively correlated. Similarly, the same was found amongst all the boys. However, the negative inverse correlation was stronger in boys, mainly in VO2 max and overall fitness (table 4). BMI and all the fitness parameters were weakly negatively associated in overweight/obese girls. BMI and overall fitness had also a weak inverse correlation. No relationship between BMI and the fitness measures, or overall fitness, was observed in normal weight individuals (table 5). Likewise, weak negative inverse association between BMI and all of the fitness measures were also found amongst the overweight/obese boys. However, almost no relationship was found in normal weight subjects (table 6).

Table 4: Correlation (Pearson coefficient r) between BMI and fitness parameters in all the girls and the boys

|  |  |  |
| --- | --- | --- |
|  | All the girls | All the boys |
| Physical fitness component | BMI | BMI |
| Flexibility | - 0.07 \* | - 0.06 \* |
| Strenght | 0.10 ‡ | - 0.13 ‡ |
| VO2 Max (ml/min/kg) | - 0.14 ‡ | - 0.33 ‡ |
| Overall fitness | - 0.15 ‡ | - 0.27 ‡ |

**\***= P <0.05, **†**= P <0.01, **‡**= P <0.001

Table 5: Correlation (Pearson coefficient r) between BMI and fitness parameters in normal weight and in overweight/obese girls

|  |  |  |
| --- | --- | --- |
|  | Normal weight | Overweight/Obese |
| Physical fitness component | BMI | BMI |
| Flexibility | - 0.01 | - 0.16**\*** |
| Strenght | 0.06**\*** | - 0.27 **‡** |
| VO2 Max (ml/min/kg) | - 0.04 | - 0.16\* |
| Overall fitness | - 0.00 | - 0.31 **‡** |

**\***= P <0.05, **†**= P <0.01, **‡**= P <0.001

Table 6: Correlation (Pearson coefficient r) between BMI and fitness parameters in normal weight and overweight/obese boys

|  |  |  |
| --- | --- | --- |
|  | Normal weight | Overweight/Obese |
| Physical fitness component | BMI | BMI |
| Flexibility | 0.03 | - 0.04 |
| Strenght | 0.16 **‡** | - 0.28 **‡** |
| VO2 Max (ml/min/kg) | 0.01 | - 0.40 **‡** |
| Overall fitness | 0.09 **‡** | - 0.33 **‡** |

**\***= P <0.05, **†**= P <0.01, **‡**= P <0.001

With regard to overall fitness score and BMI categories, the distribution of the subjects within each score is represented in Supplementary data 3 (table S7). There was a higher proportion of normal weight subjects that had an overall fitness score of 3 (46.4% of the boys and 45.5% of the girls) and 4 (17.3% of the boys and 13.8% of the girls). On the other hand, however, the overweight/obese participants had the highest percentage of individuals within 1 (14.3% of the boys and 12.8% of the girls) and 2 (48.8% of the boys and 47.2% of the girls) of overall fitness score (Supplementary data 3; table S7).

**4 Discussion**

In this cross-sectional study sample of 3692 adolescent girls and boys, aged 16-18 years old, a weak inverse association between BMI and fitness was found amongst all the girls and the boys. The negative inverse association was more strongly correlated when normal weight and overweight/obese girls and boys were separated. Lowest fitness scores were observed amongst boys and girls with the highest BMI (overweight/obese). The correlation between BMI and fitness was predominantly noticeable in VO2 max and overall fitness, especially amongst the boys. These findings support the notion that normal weight adolescents are more likely to have a higher physical fitness than overweight/obese individuals, which is also in agreement with previous studies (10-16), and also in agreement with our hypothesis. However, these studies (10-16) did only examine cardiorespiratory fitness (VO2 max) and its association to BMI and they did not take into account strength, or flexibility, which are both important components of overall physical fitness. Nevertheless, Bovet et al. (2007), Huang et al. (2009) and Joshi et al. (2012) did look at fitness tests measuring strength and flexibility. These studies did also find that normal weight individuals scored higher in not only fitness test measuring CRF, but also in strength and flexibility tests. However, overweight participants either performed as good as their normal weight counterparts or not far from it in the strength tests. Therefore, although in our study the participants with lower BMIs were more likely to achieve a higher overall fitness score compared to those with higher BMIs, it should yet be noted that a proportion of overweight/obese subjects did score a 3 or 4 in overall fitness. Similarly, few of the normal weight participants did score 1 or 2 in overall fitness. In other words, an individual categorized as overweight/obese according to BMI can still be physically fit due to the person’s muscle mass. Conversely, a person categorized as normal weight can have a poor physical fitness as a result of a low muscle mass. Thus, BMI as a tool is not always optimal.

The prevalence of overweight/obesity in FMS was higher amongst the boys compared to the girls (23.7% and 15.3% in boys and girls, respectively). Data from Statistics Sweden (Statistiska Centralbyrån, SCB) showed that the level of overweight/obesity in 2010/2011 amongst 16 to 19 years old boys in Sweden was less (15.9%) in comparison to the boys in FMS. Likewise, a smaller proportion of the 16 to 19 years old Swedish girls were overweight/obese (12.7%) in contrast to the girls in FMS (51). The weight and height of the adolescents in FMS were compared to the reference values for Swedish teenagers. Although these reference values were from 2002, they are the most recent ones. The data was based on longitudinal measurements of weight and height from birth to final height. The data came from 3650 (1801 girls and 1849 boys) healthy, full-term Swedish children and adolescents born between 1973 and 1975. However, in comparison to former Swedish growth reference values, obtained from children and teenagers born between 1955 and 1958, it has clearly been an increase in body size. For example, the renewed reference values compared to the older ones showed that girls at the age of 18 years old were 2.3 cm taller and 3.4 kg heavier, whilst boys were 1.9 cm taller and 5.7 kg heavier (49). The mean weight for both boys and girls in FMS in all ages demonstrated that they were heavier compared to the reference values, though the difference was more evident among the boys than the girls. The reason to this difference in weight is possibly due to the fact that the boys and girls in FMS were weighed with their clothes on. Additionally, the difference in weight, especially among the boys, may also be explained by the fact that boys seem to have become more interested in exercise, mainly strength training, along the years in order to build muscles. Therefore, they have become heavier as well. Data from Statistics Sweden also shows that the average weight for boys aged 16-19 years old has increased from 68.1 kg to 72.4 kg between the years 1988-89 and 2010-11 (52). This seems to also be the case in the 16 years old boys from Bäckängsgymnasiet and the 18 years old boys from the study by Sjöberg et al. (2012) in which they are also heavier compared to the reference values. Moreover, of the 540 16-18 years old boys in FMS that were classified as overweight/obese, 13.2% scored 4 in the strength tests and 2.7% scored a 5. This may also support the fact that boys have become heavier in terms of muscles over the past decade, therefore they are likely to have become bigger in terms of kilograms, thus much heavier compared to reference values from 2002. Although there are differences in mean weight between the adolescents in FMS and the Swedish reference values, they are considered to be a representative group due to that the height amongst them does not differ much. In other words, the weight can commonly be different between populations groups when compared to reference values, however the height ought not to be much different. Nevertheless, it is not completely correct to draw such conclusions that they seem to be a representative group just by looking at height. If data of the students’ parents’ educational level, ethnicity or socioeconomic status was available, it could have given a better picture of whether or not they are a representative sample.

The test-retest study revealed that the FMS questionnaire which measures physical, social and mental health in adolescents is a reliable tool to use. Almost perfect test-retest reliability was found for strength, flexibility and balance. The reliability for the parameters concerning lifestyle showed moderate to perfect agreement. Questions regarding psychological health and somatic pain as well as school environment and relationship showed substantial to almost perfect test-retest reliability. Nevertheless, stress, perceived health, diet, physical activity and drugs had low ICC values between the two test trials. When measuring a person’s perceived health or stress, it is expected to obtain moderate test-retest reliability. This is due to the fact that one’s perceived health and stress is likely to change within short time periods, even within a week interval as in this case. Obtaining higher ICC values which would be indicative of perfect agreement would instead mean that the actual question being tested is not catching these changes. Measuring diet, physical activity and drugs is however usually not due to intra-individual variability and day-to-day changes. The obtained substantial to moderate agreement is most probably attributable to under-reporting regarding diet and drugs and over-reporting in physical activity levels.

Measuring the validity of a questionnaire is difficult and it has several dimensions. However, in this study, the fitness tests used to measure cardiorespiratory fitness, VO2 max that is, have been validated elsewhere (39-43) against a criterion instrument such as a treadmill. All of the tests used in this study have shown to have a correlation factor ranging from 0.76 to 0.90, indicating to be valid tests to measure cardiorespiratory fitness. Questions regarding tobacco, alcohol and diet have also been validated previously in HLV and in Children and Young in Skåne. Comparing the results obtained in this study with data from HLV and Children and Young in Skåne were rather similar, therefore one could say that there is a relative validity to these questions. However, noteworthy is that a much larger proportion of the adolescents in HLV were non-smokers compared to the youths in FMS. This could be due to under-reporting in HLV. Although the questionnaire is anonymous, the boys and girls in HLV might have been frightened that they would get told-off if they filled in that they were cigarette users which therefore may explain this large difference. It could also mean that the results obtained in FMS are more reliable since the students are sitting with an instructor while answering the questions instead of filling it in themselves. By doing so, it is more unlikely that under-or- over-reporting occur. The FMS questionnaire is therefore believed to be a reliable and relative valid tool to use.

Overweight and obesity have been shown in our study, but also elsewhere, to be associated with low physical fitness among adolescents. Since being overweight and obese during childhood and adolescence is likely to be followed into adulthood, it is of outermost importance to halt the increasing prevalence. Being overweight and/or obese can cause terrible consequences. It can lead to other diseases such as, for example the metabolic syndrome (hypertension, hyperglycemia, dyslipidemia) (53). All of these illnesses are in turn risk factors for cardiovascular disease (CVD) such as heart disease. The developing atherosclerotic process of heart disease starts early in childhood and adolescences and track into adulthood if one or many of the risk factors are present (54). Similarly, it has been proposed that low physical fitness is associated with the clustering of these CVD risk factors in European (55) and American teenagers (56). Therefore, being overweight and/or obese along with having a low physical fitness increases the risk of developing CVD later in life. Besides the physical consequences of being overweight and obese, there are psychosocial concerns as well. Adolescents who are overweight or obese often suffer from having a low self-esteem, social isolation and having an increased risk of developing depression. In addition, when dealing with such a group as adolescents, it is important to not only try to solve the overweight and/or obese problem by increased physical activity and healthy eating. It is also necessary to take into account the actual problem that may be the underlying cause to why an individual has become overweight or obese. In many cases, traumas of some kind, bullying or not thriving in school are examples of some underlying bases which must be handled as well (57). Not only is overweight and obesity a burden for the individual, but also for the society. Three billion Swedish crones are spent on obesity and obesity-related diseases per year. On top of that, the indirect costs for sick leave and early retirements are also tremendously high (58). Having said that, the promotion of physical fitness through physical activity has to be increased and improved in the school settings.

When carrying out such a study as ours, the research ethics is very important. All the participants and their parents’/guardians’ have to agree to take part. Ensuring that all participants and their parents’/guardians’ have been well informed regarding the benefits and the risks is also essential. All the information from the participants is carefully, securely and anonymously handled. By participating in our study, the students have been provided with motivational talks with either an instructed nurse or PE teacher. The aim for the nurse/PE teacher has been to bring up the student’s own thoughts of his/her own lifestyle behavior and give advice on how to change it. The nurse/PE teacher has also followed some principles during the talk. These include supporting self-reliance, showing empathy, avoiding arguments and having a collaborative approach as well as showing to be an equal partner instead of patronizing. The students have also been taught how to correctly perform strength and flexibility exercises by experienced PE teachers. Furthermore, participating in the FMS study does not really include any risks except if the participants would injure themselves while carrying out any of the fitness tests, however they have been informed about that prior to agreeing to participate. Having a student profile, such as the one conducted by FMS, which assesses physical, social and mental health among adolescents is very important. This can help schools who decide to use the student profile to acquire an overview of the health among the students. Subsequently, the school can work on improving the health by implementing certain measure and interventions.

The strengths of this study were that the anthropometric measurements and the fitness was tests were conducted by experienced nurses and PE teachers. All the equipment and the fitness tests were standardized. Additionally, the large sample size was also a strength in our study. Moreover, the fact that a test-retest study was included is also unique to our study. Although BMI is a useful tool to use in large populations, particularly among children and adolescents, solely using it alone to assert an association to physical fitness was a limitation. Instead, measurements of body fat and muscle mass (which was measured in our study, but only in a small number of individuals) ought to be used together with BMI. Another limitation was that the adolescents were weighed with their clothes on, which does not provide an accurate measurement. Also, physical activity pattern was measured in this study, however it was only done in a very small proportion of the study population which is a drawback. Physical fitness depends on genetics and other non-modifiable factors (age, gender etc.). However, the foremost controllable factor is physical activity (2). Since data on PA habits were not complete in our study, the relative contribution of it cannot be determined. In addition, whether or not there is a correlation between the measured VO2 max and the amount of PA reported in the questionnaire cannot be asserted either. The fact that a large number of students were excluded since data on weight and height was not available is also another limitation that could have influenced the results. Lastly, the cross-sectional design of this study is also a limitation in which it can only show an association and not causality, therefore the results ought to be looked at with carefulness. However, it is rational to believe that adolescents with higher BMI values will also score lower in fitness tests.

**5 Future Recommendations**

In order to combat the alarming rates of overweight and obesity among adolescents, the promotion of physical activity has to be improved, particularly in schools. Suggestions include group activities, walking and cycling in groups to and from school and increasing the number of days (at least two to three days per week) of PE sessions. Additionally, providing the students with education on food and nutrition as a part of the school curriculum ought to be included. Since BMI as a tool has some disadvantages in which it does not distinguish between fat mass and muscle mass, including the measurement of body fat in percentage as well as estimated muscle mass for more accurate result ought to be provided in future studies. Additionally, physical activity levels ought to be collected in order to assert any correlation between reported physical activity habits and actual measured VO2 max. Beyond this, tackling overweight and obesity requires action, not only from the schools, but also the government, communities and families. In order to promote physical activity, there has to be a supportive environment which makes physical activity the easiest option. Being physically active ought to be something that is easy and accessible, therefore the government and municipalities must prioritize the building of sports and recreation facilities, parks, green spaces as well as walking and cycling lanes in order to promote active travel.

**6 Conclusion**

This study demonstrated a weak inverse relationship between BMI and fitness among adolescent girls and boys. The relationship was strongest in regards to cardiorespiratory fitness and strength and less so for flexibility. The test-retest study revealed that the FMS questionnaire is a reliable tool to use. Almost perfect test-retest reliability was found for strength, flexibility and balance. The reliability for the parameters concerning lifestyle showed moderate to perfect agreement. Questions regarding psychological health and somatic pain as well as school environment and relationship showed substantial to almost perfect test-retest reliability. Although our study found a weak negative association between physical fitness and BMI, normal weight individuals are more likely to have better physical fitness compared to overweight/obese individuals. By including various fitness measures such as cardiorespiratory fitness, muscular strength and flexibility, will provide a more complete understanding and assessment of physical fitness. In addition, including an overall fitness score provide a quick view of one’s physical fitness, which is also easily understandable for people who may not be within the fitness or health field. Having said that, overweight and obesity is not only about the weight itself, it is so much more to it. It is a disease that is multidimensional and there is not only one cause to it. Thus, when tackling the issue, focus must also be put on not only physical activity, but also nutritional education, social and mental health. Furthermore, all stakeholders such as the government, the municipalities, community, schools and families must be involved.

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**8 Authors’ contributions**

AW was responsible for the development of the FMS tool, data collection and designed this study. Helen Yohannes contributed to the study design, data collection in the test-retest study and was responsible for data cleaning, data analysis as well as prepared this thesis report. ML contributed with support when designing the study and analyzing the data. Both supervisors provided comments on the master thesis report and approved the final version.

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Supplementary data 1: Description of ranges 1-5 in cardiorespiratory fitness (VO2 max), strength and flexibility

Table S1: Description of the ranges 1-5 depending on VO2 max in ml/O2/kg

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  |  | **1 very low** | **2 low** | **3 medium** | **4 high** | **5 very high** |
| **Women** | **L O2/min** | -1,7 | 1,8 – 2,1 | 2,2-2,6 | 2,7-2,9 | 3,0­ |
|  | **ML O2/kg** | -29 | 30-37 | 38-45 | 46-52 | 53­ |
| **Men** | **L O2/min** | -2,1 | 2,2-2,8 | 2,9-3,5 | 3,6-4,2 | 4,3­ |
| **ML O2/kg** | -32 | 33-39 | 40-47 | 48-55 | 56­ |

Supplementary data 1

Table S2: Strength ranges for 16-19 years old

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **1**  **Very weak** | **2**  **weak** | **3**  **medium** | **4**  strong | **5**  Very strong |
| Sitting-chairmen | 0 - 37 | 38 – 105 | 106 – 163 | 164 – 231 | 232- |
| Sitting-chair women | 0 – 27 | 28– 80 | 81 – 126 | 127 – 180 | 181 - |
| Belly-back dynamic men | 0 – 13 | 14 – 34 | 35 – 53 | 54 – 74 | 75- |
| Belly-back dynamic women | 0 – 11 | 12 – 32 | 33 – 51 | 52 – 72 | 73 - |
| Belly-back static | <4 sec | 5 – 31 | 32 – 58 | 59 –179 | >180 |
| Arm-lift men10 kg | 0 – 5 | 6 – 15 | 16 – 24 | 25 – 34 | 35 - |
| Arm-lift men5 kg | 0 – 3 | 4 – 29 | 30 – 52 | 53 – 79 | 80 - |
| Arm-lift women5 kg | 0 – 8 | 9 – 19 | 20 – 28 | 29 – 39 | 40 - |
| Sit-ups man | 0 – 18 | 19 – 46 | 47 – 70 | 71 – 98 | 99 - |
| Sit-ups women | 0 – 10 | 11 – 35 | 36 - 56 | 57– 81 | 82 - |

**NOTE: The table shows results from a normal distribution curve from the FMS database. 4610 individuals**

Supplementary data 1

Table S3: Flexibility ranges 1-5

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **1** | **2** | **3** | **4** | **5** |
| 6 or more exercises need to stretch | 5 of the exercises need to stretch OR  Risk factor of back / shoulders / neck  although only 1 exercise requires stretch. | 3-4 of the exercises need to stretch | 2 of the exercises need to stretch | all exercises good |

1-2= risk factor for future health problems

3-5= healthy factor which can prevent future health problems

Supplementary data 2: Figures

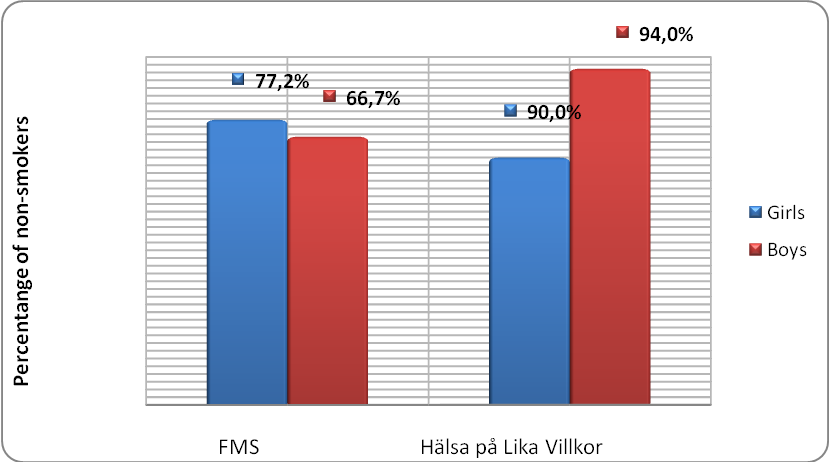


Figure S1: Proportion of non-smokers in 16-18 years old boys and girls in FMS and 16-19 years old boys and girls in HLV

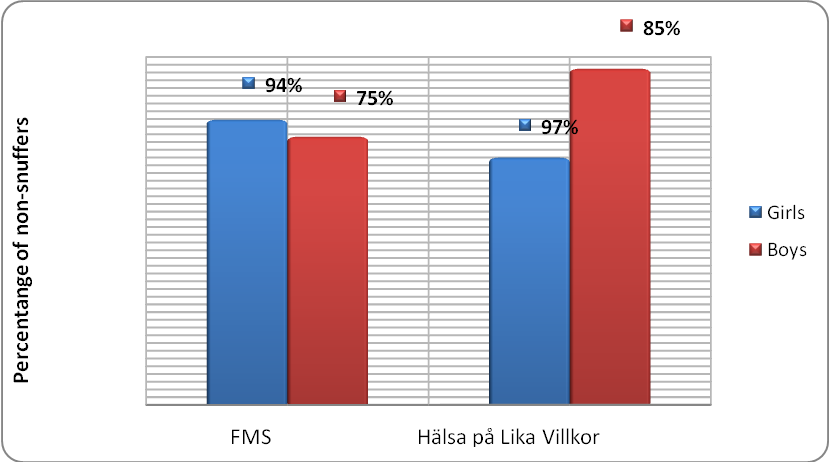


Figure S2: Proportion of non-snuff users in 16-18 years old boys and girls in FMS and 16-19 years old boys and girls in HLV

Supplementary data 2: Figures

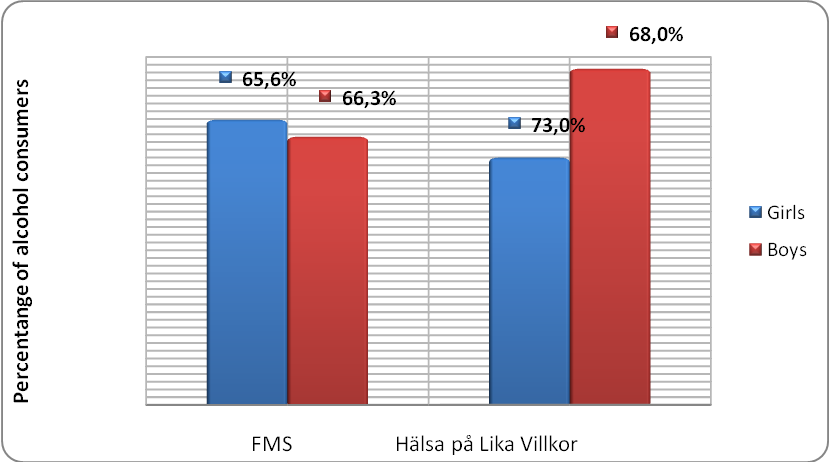


Figure S3: Proportion of alcohol consumers in 16-18 years old boys and girls in FMS and 16-19 years old boys and girls in HLV

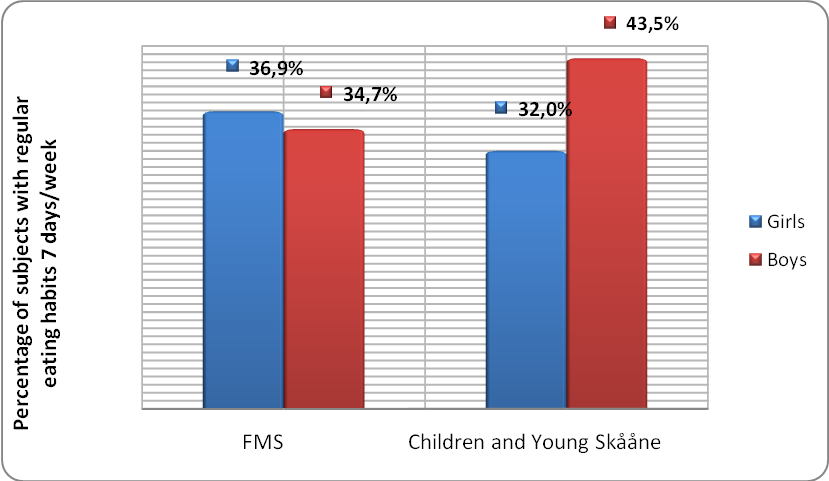


Figure S4: Proportion of 16-18 years old boys and girls in FMS and 16-19 years old boys and girls in Children and Young Skåne with regular eating habits 7 days/week

Supplementary data 3: Tables

Table S1: Mean weight and height in 16-18 years old boys in FMS and mean weight and height from reference values

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | FMS | Reference values | FMS | Reference values |
| Age | Weight (kg) | Weight (kg) | Height (cm) | Height (cm) |
| 16 år | 71.6 ± 13.3 | 65.9 | 178.9 ± 7.0 | 177.1 |
| 17 år | 73.4 ± 13.6 | 68.7 | 179.6 ± 7.1 | 178.7 |
| 18 år | 76.2 ± 14.7 | 72.2 | 180.4 ± 6.7 | 178.7 |

Table S2: Mean weight and height in 16-18 years old girls in FMS and mean weight and height from reference values

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | FMS | Reference values | FMS | Reference values |
| Age | Weight (kg) | Weight(kg) | Height (cm) | Height (cm) |
| 16 år | 60.4 ± 9.6 | 58.5 | 166.7 ± 6.4 | 166.7 |
| 17 år | 61.4 ± 10.0 | 59.0 | 166.9 ± 6.3 | 166.6 |
| 18 år | 61.5 ± 9.8 | 61.3 | 166.7 ± 7.3 | 166.6 |

Table S3: Mean weight and height in18 years old boys in FMS, reference values and Sjöberg et al. (2012)

|  |  |  |  |
| --- | --- | --- | --- |
|  | FMS | Sjöberg et al. 2012 | Reference Values |
| Weight  (kg) | 76.2 | 74.4 | 72.2 |
| Height (cm) | 180.4 | 180.3 | 178.7 |
|  |  |  |  |

Table S4: Mean weight and height in 16 years old boys in FMS, Bäckängsgymnasiet and reference values

|  |  |  |  |
| --- | --- | --- | --- |
|  | FMS | Bäckängsgymnasiet | Reference Values |
| Weight (kg) | 71.6 | 70.7 | 65.9 |
| Height (cm) | 178.9 | 177.1 | 177.6 |

Table S5: Prevalence of overweight/obese in boys and girls in FMS

|  |  |  |
| --- | --- | --- |
|  | Overweight/Obese | Normal weight |
| Boys | 23.7% | 76.3% |
| Girls | 15.3% | 84.7% |

Table S6: Distribution of the girls within each fitness score

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  | Overall Fitness Score | |  |  |
| Girls | 1 | 2 | 3 | 4 | 5 |
| BMI categories | Number (%) | Number (%) | Number (%) | Number (%) | Number (%) |
| Normal weight | 95 (7.5) | 424 (33.0) | 585 (45.5) | 178 (13.8) | 4 (0.3) |
| Overweight/Obese | 30 (12.8) | 110 (47.2) | 77 (33.1) | 16 (6.9) | 0 (0) |

Table S7: Distribution of the boys within each fitness score

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  | Overall Fitness Score | |  |  |
| Boys | 1 | 2 | 3 | 4 | 5 |
| BMI categories | Number (%) | Number (%) | Number (%) | Number (%) | Number (%) |
| Normal weight | 73 (4.4) | 419 (31.3) | 771 (46.4) | 287 (17.3) | 8 (0.5) |
| Overweight/Obese | 73 (14.3) | 251 (48.8) | 164 (31.9) | 24 (4.7) | 2 (0.4) |