Physical Therapy as Treatment for Childhood Obesity in Primary Health Care: Clinical Recommendation From AXXON (Belgian Physical Therapy Association)

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The prevalence of obesity in children and adolescents has increased by 3- to 4-fold over the last 3 decades in the United States.[1] In Europe, current prevalence rates of overweight or obesity in preschool children are between 8% and 13%.[2] Obesity has major health and socioeconomic impacts, especially in children and adolescents.[3] These populations are at greater risk for developing endothelial dysfunction, hypertension, insulin resistance, cholecystolithiasis, nonalcoholic fatty liver disease, and respiratory and orthopedic disorders and for having psychosocial or psychiatric problems, chronic pain, and lower quality of life.[4–8] Childhood obesity alone has been estimated to cost $14 billion in the United States annually in direct health expenses,[9] and these high costs have been confirmed in Europe.[10] Obesity in children and adolescents should be considered a severe pathologic state, and maximal efforts should be made to improve prevention of and therapy for obesity in children and adolescents. To generate fat mass loss in children and adolescents with obesity, an increase in caloric expenditure (activity promotion) and a reduction in caloric intake are important.[11,12] Physical activity related to recreation and transportation should be increased, sedentary activities should be reduced, and regular structured exercise should be achieved.[11,12]

It is often implicitly assumed that increased physical activity is feasible and medically safe in children and adolescents with obesity. Given the increased likelihood for the development of comorbidities in children and adolescents with obesity (such as orthopedic injuries or limitations, asthma, exercise hypertension, insulin resistance, and diabetes)[4,13–17] and their potential role as exercise-limiting factors, a correct interpretation of someone's physical capacity and associated physical limitations is needed. Therefore, children and adolescents who have obesity and who intend to increase their level of physical activity should be evaluated and monitored by physical therapists because of their knowledge of pathology, pharmacotherapy, and exercise physiology. Systematic involvement of physical therapists in the treatment of obesity in children and adolescents can result in a more comprehensive evaluation and improved care and treatment of obesity at the community level, especially in children and adolescents with increased health care needs.[18] In addition, multidisciplinary interventions are important for addressing the specific needs of the patient and maximizing treatment effectiveness. Unfortunately, the expertise of physical therapists is currently underrecognized and underused in the prevention and treatment of obesity in children and adolescents.[19]

Most physical therapists are active in private and home care (first-line) settings. These primary health care providers are not always adequately equipped with clinical practice guidelines, complex or expensive assessment tools, and treatment resources for dealing with the pediatric obesity epidemic.[20] Therefore, it is essential to provide guidelines on how to execute a preparticipation screening and increase the medical safety and effectiveness of exercise interventions, given the limited infrastructure and assessment tools that are available to physical therapists in private and home care settings. In addition, to overcome limitations in terms of equipment for evaluations, physical therapists should collaborate closely with institutions that or health care providers who offer complex or expensive evaluation methods and should obtain access to the health information provided by these methods.

The aim of this clinical recommendation is to provide physical therapists in first-line settings with a systematic, effective, and feasible approach for prescribing clinically effective and medically safe exercise interventions for children and adolescents with obesity. In this article, children are considered to be 6 to 12 years of age, and adolescents are considered to be 12 to 18 years of age.

Recommendation Methodology

This recommendation was developed within AXXON (Belgian Physical Therapy Association). How the preparticipation tests were selected in a systematic manner is explained in Appendix 1.

Preparticipation tests are clinical evaluations that are applied before exercise participation with the aims of detecting potential limitations or difficulties in exercise participation, verifying adequate medical safety of exercise participation, and evaluating health and physical activity parameters. Preparticipation tests should be feasible (low cost and easy to execute) in private and home care physical therapy settings and should be valid and reliable in children and adolescents with obesity. In a first group discussion, we decided which patient characteristics had to be examined before an exercise intervention. On the basis of this discussion, we decided that the following items and patient characteristics should be screened before an exercise intervention: medical safety,

Table 1.
Key Words Used and Number of Relevant Hits in Literature Search for Preparticipation Tests and Exercise Interventions

Item	Key Words	No. of Hits	Relevant References
Physical activity	Physical activity, assessment (limited to "child," "review," and/or "practice guideline")	1,598	43, 44
Weight status and body composition	Assessment, fat mass (limited to "child," "review," and/or "practice guideline")	64	24, 25, 42, 49, 51
	Assessment, fat mass, validity (limited to "child")	46	24, 25, 42, 49, 51
	Assessment, waist circumference, validity (limited to "child")	32	24, 25, 42, 49, 51
Endurance exercise capacity	Assessment, physical fitness (limited to "child," "review," and/or "practice guideline")	275	56, 57
Muscle strength	Assessment, muscle strength (limited to "child," "review," and/or "practice guideline")	55	56, 57, 60
Exercise intervention	Exercise training (limited to "child," "review," and/or "practice guideline")	870	11, 12, 69, 72, 73
	Physical activity (limited to "child," "review," and/or "practice guideline")	3,184	11, 12, 69, 72, 73

physical activity, weight status, body composition, and physical fitness. After a systematic literature search for reliable, valid, and feasible tests and reports of the outcomes of these tests, a group consensus about which tests should be used in private and home care physical therapy settings was reached in 2 subsequent meetings.

The key words used and the number of relevant hits in the systematic literature search are shown in Table 1. The key words were a combination of Medical Subjects Headings (MeSH) terms and self-selected terms and were chosen to include as many relevant articles as possible. A summary of how to screen children and adolescents with obesity and how to increase medical safety and clinical benefits of exercise interventions is shown in Appendix 2, and these processes are explained in greater detail later in this article. A system based on the work of Harbour and Miller[21] was applied to define the level of evidence and the grade of recommendation. This grading system is further explained in Appendix 3.

Definition of Obesity in Children and Adolescents

According to the International Obesity Task Force, the cutoff point for obesity corresponds to an adult body mass index (BMI) of 30 kg/m². [12,22] According to the Centers for Disease Control & Prevention, the threshold for obesity in children and adolescents equals the 95th percentile of the age- and sex-specific BMI in people younger than 19 years. [23,24] The World Health Organization proposes different criteria for obesity in children and adolescents: obesity is diagnosed when the BMI is greater than 2 standard deviations above the World Health Organization growth standard median (for ages 5–19 years). [3] These different criteria may yield somewhat different thresholds for the diagnosis of obesity, and this possibility should be taken into account in clinical practice. To maximize the specificity and sensitivity of diagnosing obesity in children and adolescents, clinicians should consult region- and ethnicity-specific BMI charts. [25]

When obesity is suspected in a child, whether the elevation in the BMI is due to an elevation in fat mass or fat-free mass should be determined. [26,27] In children

and adolescents with obesity, elevations in fat-free mass are often present (due to long-term increased muscular load during walking, running, and cycling) along with elevations in fat mass. [28] Therefore, different types of body tissues should be discriminated. The BMI should be considered a triage instrument, and further examination is warranted to examine whole-body fat mass when a child or adolescent is believed to be obese. In this regard, measurement of skinfold thickness, waist circumference, or both or medical imaging techniques may be used. [27] The clinical relevance, feasibility, and validity of these methods are discussed later in this article.

Preparticipation Screening in Children and Adolescents With Obesity

Before the initiation of an exercise intervention in children and adolescents with obesity, a preparticipation screening that is feasible for physical therapists working in private and home care settings should be executed. This screening will contribute to the detection of potential obesity- or exercise-related complications; the quantification of physical activity, body composition, endurance exercise capacity, and muscle strength; and the detection of potential internal and external barriers to exercise participation.

Medical Safety (Level of Evidence: 2+; Grade of Recommendation: C)

First, physical therapists should execute a thorough medical history check, including reporting of previous diseases, current medical problems or symptoms, and medication prescriptions.

Respiratory medications (antihistamines or medications for obstructive airway diseases) are prescribed significantly more often in children and adolescents with obesity. [29] When these respiratory medications are prescribed for a child, their administration should be adjusted according to respiratory symptoms experienced during exercise training. For example, when asthmatic symptoms develop during exercise, bronchodilators should be administered to allow the child to continue exercising. Adoles-

cents (>12 years old) with obesity can take medications to facilitate fat mass reduction, such as orlistat.[30] Gastrointestinal symptoms, which are a common side effect of orlistat intake, can interfere with exercise training and therefore should be monitored by physical therapists. When side effects cause too much interference with exercise, orlistat therapy should be discontinued (in consultation with the physician).

Type 2 diabetes is observed more often in children and adolescents with obesity.[13] It is treated with oral metformin (first choice) or exogenous insulin administration.[31] However, exogenous insulin therapy elevates the risk for hypoglycemia during and after exercise; metformin does not lead to an elevated risk for hypoglycemic episodes. Therefore, insulin therapy should be adjusted carefully to the planned exercise training (in collaboration with the diabetes nurse or treating physician).[32] Referral to a physician is advised when changes in medication prescriptions are required.

Next, physical therapists should measure resting heart rate and blood pressure. Resting heart rate should be measured (by radial artery palpation) immediately before blood pressure is measured (recommendations for proper measurement are provided later). Elevations in resting heart rate in children and adolescents are often associated with hypertension, dyslipidemia, impaired fasting glucose, or a combination of these.[33–35] It follows that an elevated resting heart rate may indicate accelerated atherosclerosis.[35] However, heart rate is inversely related to age. Given these circumstances, physical therapists should consult region- and ethnicity-specific age-adjusted reference charts for a proper interpretation of the resting heart rate.[36]

Blood pressure should be measured with a manual sphygmomanometer (with the correct cuff size) and stethoscope; the child should sit comfortably for at least 5 minutes on a chair (with the back supported and the legs not crossed), and the measured arm (always the same arm) should be at the level of the heart (supported by the physical therapist) and freed from all clothing. The child should

not consume caffeine-containing drinks, smoke cigarettes, or perform exercises for more than 30 minutes before the assessment and should not talk during the measurement. The cuff should be inflated to at least 30 mm Hg above the point at which the radial pulse disappears and should be deflated at 2 to 3 mm Hg/s. Blood pressure should be measured at least twice (with averaging of results).[37] Hypertension should prompt further attention, clinical examination, or both, and referral (back) to a physician is advised.[38] Children and adolescents with obesity have a higher prevalence of hypertension.[14] However, blood pressure also is related to age; a young child will have a lower blood pressure than an adolescent. Given these circumstances, physical therapists should consult region- and ethnicity-specific age-adjusted reference charts for a proper interpretation of blood pressure.[39] Exercise programs can have a beneficial effect on both systolic and diastolic resting blood pressure in children with obesity.[40] This is why blood pressure is an important outcome parameter.

Second, the respiratory system should be evaluated. Childhood obesity can have an impact on pulmonary mechanics, appears to be linked to asthma, and increases the risk for sleep-disordered breathing.[15] Physical therapists need to verify the degree of ventilatory limitation that can be present during exercise, whether atelectasis is present, or both. Tachypnea can alert physical therapists to execute a thorough pulmonary system examination, but this condition can be diagnosed only when age-adjusted charts are used.[36] Training modalities, intake of pulmonary medications, or both can then be adjusted accordingly (in consultation with the physician).

Third, the orthopedic system should be examined. Children and adolescents with obesity are at an increased risk for the development of chronic musculoskeletal pain, acute musculoskeletal injuries and bone fractures during vigorous exercise, low back pain, flatfoot, Blount disease, and a slipped capital femoral epiphysis.[4,16,17] Therefore, physical therapists should perform a thorough musculoskeletal examination (including visual

and tactile inspections) and should adapt training modalities and exercise programs accordingly. In particular, changes in exercise type (eg, walking, cycling, and swimming) and volume or intensity may be relevant.

Finally, psychosocial barriers or comorbidities should be inventoried during the intake interview. These psychosocial parameters can best be evaluated in conjunction with a psychologist. Low self-esteem and self-efficacy, lack of motivation, anxiety about exercising, and embarrassment about exercising (outdoors) can significantly suppress exercise therapy adherence and lead to premature dropping out and should be addressed. A negative body image, a perception of being negatively judged and verbally bullied, a perception of having lower athletic abilities, feeling fatigued during and after exercise, and repetitive failure to lose fat mass are more likely to be present in children and adolescents with obesity and can negatively affect adherence to exercise prescription.[41,42] In addition, social support (from peers, friends, and family) in the attempt to lose fat mass is important.[41,42]

The intake interview also can include an examination of whether environmental and external barriers to exercise participation are present. An inadequate level of privacy; rainy, cold, or hot weather; a lack of resources or facilities; a lack of safety; and the presence of inhibitory social norms are very likely to inhibit exercise participation in adolescents with obesity.[41,42] The behavior of peers and other participating children and adolescents is important; adolescents with obesity are less likely to continue exercising when they are bullied physically or verbally, stereotyped, or socially excluded.[41] Additionally, a lack of knowledge about the benefits of exercise training or which type of exercise is effective for reducing fat mass can affect adherence to exercise programs in children and adolescents with obesity.[41]

On the basis of a thorough clinical examination, physical therapists should be sufficiently aware of absolute or relative contraindications to exercise training or anomalies that require changes in the

exercise program. In the following situations or conditions, children and adolescents with obesity should be referred (back) to a physician before the initiation of an exercise intervention: untreated or previously unknown hypertension, severely disabling or limiting orthopedic anomalies, severely disabling or limiting pulmonary dysfunction, or significant internal barriers to exercise participation that can lead to premature dropping out and cannot be affected by a physical therapist. When less disabling or limiting pulmonary or orthopedic disease is present or when internal or external barriers to exercise participation are discovered, the exercise program should be adjusted accordingly or the patient should be prompted to undertake appropriate actions.

In conclusion, during the first part of the preparticipation screening, physical therapists screen medication prescriptions; examine the cardiovascular, respiratory, and orthopedic systems; and examine whether potential internal and external barriers to exercise training are present.

Physical Activity (Level of Evidence: 1+; Grade of Recommendation: A)

Children and adolescents with obesity are less engaged in an active lifestyle.[43] It is important to use valid and reliable assessment tools to measure the amount of physical activity performed by children and adolescents with obesity.[44] Subjective tools (questionnaires) are most commonly used for the assessment of physical activity in children and adolescents with obesity because of their low cost and feasibility. Of 61 questionnaires that can be administered in children and adolescents in general, none were found to be sufficiently reliable and valid.[45] Of those questionnaires, only 7 received a positive rating for reliability, and the intraclass correlation coefficients ranged from .49 to .87.[45] Correlations between accelerometry and physical activity questionnaires (construct validity) were low in children of preschool age (up to $r=.42$) but were higher in adolescents (up to $r=.77$).[45] Typical problems with currently available questionnaires are overreporting of physical activity,

greater recall bias in younger children, lack of awareness of what exercise truly is, inability to report exercise intensity, and influence of self-esteem on physical activity reporting. In addition, data specifically about the reliability and validity of physical activity questionnaires in children and adolescents with obesity are scarce. Hence, objective techniques for measuring physical activity in children and adolescents with obesity are preferred.

Many objective techniques and devices for examining physical activity are currently available; they include pedometers, accelerometers, load transducers, heart rate monitors, multiple-sensor systems, and global positioning systems.[44] One common limitation is that children and adolescents (including those with obesity) do not like to wear motion sensors because of embarrassment. Therefore, it is important to use monitors that can be concealed but to measure long enough to collect valid data (at least 3 consecutive days).

Pedometers are simple and relatively inexpensive devices for objectively measuring physical activity in children and adolescents with obesity. However, measurement error in these populations is too high,[44] probably because the inability to wear pedometers in an exactly vertical plane makes counting steps in a reliable fashion difficult. In addition, especially at lower walking speeds, pedometers are not sufficiently reliable and valid ($\sim$100% error for step counting at a walking speed of 0.5 mph, compared with observation).[46] Unfortunately, children and adolescents with obesity typically prefer to walk at lower speeds.[47] Finally, pedometers cannot record upper body or horizontal movement. Therefore, pedometers are robust, convenient, and cost-effective for assessing physical activity in children and adolescents with obesity but are less precise than other devices.

Accelerometers are somewhat more sophisticated physical activity monitors and are easy to wear. The reliability and validity of currently available accelerometers for the assessment of physical activity in children and adolescents vary

greatly,[44] although they are suspected to be higher than those of pedometers (eg, in children who are overweight, pedometers have 100% error for step counting at a walking speed of 0.5 mph, whereas accelerometers have 24% error).[46] Some accelerometers are even capable of measuring sleep quality (which may be important for some children and adolescents with obesity). No specific accelerometer has been proven to have the best validity and reliability in children and adolescents with obesity. Triaxial accelerometers collect physical activity data that are more precisely matched to actual energy expenditure, as opposed to uni- or dual-axial accelerometers,[44] and, therefore, are preferred in clinical practice. However, accelerometers and associated software are more expensive than pedometers, and the analysis of physical activity data provided by accelerometers may be more complex.

Heart rate monitors can provide a very reliable and valid estimation of physical activity because of the linear increase in proportion to exercise intensity and caloric expenditure, but these monitors are limited by higher cost and discomfort in wearing.[45] Most children and adolescents are reluctant to wear such monitors for a few days. In addition, heart rate monitors are less accurate in estimating energy expenditure during low-intensity exercises; data processing can be laborious; some heart rate monitors are vulnerable to signal interference from computers, televisions, and other heart rate monitors; and the constant exposure to electrodes may cause skin irritation. As a result, heart monitors are often not appropriate for quantifying physical activity in children and adolescents.

During sports (and especially during competition events), wearing some of these physical activity monitors is not allowed by coaches, referees, or both. In such situations, missing data should be taken into account during the interpretation and analysis of physical activity. If possible, these monitors should be worn during physical activity to obtain a proper quantification of physical activity.

Data about the validity and reliability of load transducers, global positioning

systems, multiple-sensor systems, and "wearable technology," such as watches and bracelets that connect to smart phones or tablets, for the assessment of physical activity in children and adolescents with obesity are scarce.[44] Therefore, these devices are currently not recommended for the assessment of physical activity in children and adolescents.

In conclusion, there is no perfect monitor for measuring physical activity in children and adolescents with obesity. However, given all of the strengths and weaknesses of available physical activity monitors, accelerometers are recommended because they are easy to wear, not too costly, and easy to hide from other children; in addition, they provide additional information, such as caloric expenditure and exercise intensity, but the validity of this information should be interpreted with care in children and adolescents with obesity. Such monitors can be used to observe changes in physical activity levels or to aid in prescribing physical activity increases.

Weight Status

The BMI is often used to rapidly discriminate between children who have obesity and those who do not have obesity, but it cannot distinguish between lean tissue mass and fat mass.[27] However, the relationship between the BMI and adipose tissue (measured by medical imaging techniques) becomes stronger as fat mass increases in children and adolescents.[27] On the other hand, changes in the BMI as a result of exercise interventions can be due to changes in fat mass or lean tissue mass. In addition, in children and adolescents with obesity, elevations in fat-free mass—further increasing body weight—are often present.[28] The BMI actually reflects a composite of several aspects of body composition and structure, including skeletal (bone) mass, skeletal muscle mass, organ mass, adipose tissue mass, body fat distribution, limb and trunk length, hydration of fat-free mass, and stature.[48] Therefore, examination techniques that discriminate between fat mass and fat-free tissue mass should be incorporated into the evaluation of children and adolescents with obesity. In conclusion, weight status is

most often assessed with the BMI, but great caution in attempts to categorize children and adolescents as lean or obese is advised.

Body Composition (Level of Evidence: 1+; Grade of Recommendation: A)

Lean tissue mass and fat mass have different implications for health status and the clinical management of a variety of childhood diseases.[49] Therefore, it is important to obtain a proper determination of fat mass. Moreover, visceral fat mass is an important contributor to the development of type 2 diabetes and cardiovascular disease. Therefore, it may be important to obtain a quantification of trunk fat mass.[48]

A noninvasive and probably frequently used technique for the study of fat mass is the skinfold thickness measurement. Good candidates for the measurement of extremity and trunk subcutaneous fat deposits are triceps and subscapular sites, whereas subscapular and abdominal skinfolds are preferred for the estimation of trunk fat.[50] However, skinfolds are subject to large measurement errors because of difficulty in obtaining a qualitatively good skinfold and the impact of the experience of the examiner.[27] In addition, no correlation or poor correlations between changes in fat mass (as measured by dual-energy x-ray absorptiometry) as a result of exercise interventions and changes in skinfold thickness in children and adolescents with obesity were found.[51] Therefore, the measurement of skinfolds for the estimation of changes in whole-body fat mass in children and adolescents with obesity is currently not recommended. The recommendation for physical therapists who still intend to obtain skinfold thickness measurements in children and adolescents is that the measurements be reported in raw form or as a standard deviation score.[52]

Another feasible method for estimating whole-body fat mass in children and adolescents with obesity is measurement of the waist circumference. However, the addition of the waist circumference measurement to the BMI calculation did not add information about body composition

in children and adolescents with obesity in cross-sectional evaluations.[26] In addition, the waist circumference and the BMI are equally useful for monitoring the consequences of obesity in young adults.[53] However, more authors and international federations now support the use of the waist circumference or the waist-to-hip ratio for the assessment of fat mass in children and adolescents and argue that such measurements may be preferable for the classification of obesity in children and adolescents.[48,54] Monitoring the waist circumference may provide a better indication of health risks in children and adolescents with obesity because the main concern in these patients is central adiposity.[52] In addition, the waist circumference may be an interesting measurement for assessing changes in fat mass during follow-up; decreases in the waist circumference during exercise interventions are entirely related to reductions in fat mass and are independent of changes in lean tissue mass.[52] These arguments and findings make the waist circumference more interesting than the BMI for monitoring changes in fat mass as a result of interventions. The methodology used to assess the waist circumference should be standardized. The circumference should be measured just above the iliac crest, with the patient standing, bare midriff, after the patient has exhaled, with both feet touching and arms hanging freely.[55] The nonelastic measuring tape should be placed perpendicular to the long axis of the body and horizontal to the floor and applied with tension without exerting pressure on the abdominal wall.[55]

The final clinically feasible and easy method that could be considered for the measurement of fat mass is bioelectrical impedance analysis. This examination should be executed after an overnight fast of 8 to 12 hours, and conditions such as room temperature, fluid intake, and physical activity or exercise preceding the examination should be standardized rigorously.[50] Many devices, including hand-to-foot, hand-to-hand, and foot-to-foot devices, are commercially available. In addition, numerous prediction equations for whole-body fat mass are available. The many available options contribute to significant variations in the

estimation of whole-body fat mass. Unfortunately, bioelectrical impedance analysis cannot accurately estimate whole-body fat mass in children and adolescents.[56] In addition, because of the enormous number of combinations of devices and prediction equations, which device and which prediction equation are most valid, reliable, and responsive for assessing whole-body fat mass in children and adolescents currently remain uncertain.[56] Therefore, estimates of whole-body fat mass by bioelectrical impedance analysis should be interpreted with great caution.

In conclusion, for cross-sectional evaluations of body composition in children and adolescents with obesity, no single rapid, noninvasive, and feasible method with sufficient validity, reliability, and responsiveness is currently available for physical therapists in private and home care settings. For cross-sectional evaluations, physical therapists should consider referring children and adolescents with obesity to health care professionals who or institutions that offer medical imaging techniques such as dual-energy x-ray absorptiometry and magnetic resonance imaging or whole-body air displacement plethysmography. On the other hand, during follow-up, measurement of the waist circumference may be preferable for observing changes in fat mass. In this regard, physical therapists are advised to assess and report changes in percentile scores for waist circumference, along with changes in absolute values.

Physical Fitness

Endurance exercise capacity (level of evidence: 2++; grade of recommendation: B). The assessment of endurance exercise capacity is important because it provides feedback to physical therapists and patients about the clinical effectiveness of exercise interventions. Also, greater endurance exercise capacity is related to reduced cardiovascular disease risk and better quality of life and general health in children and adolescents.[57] Moreover, a high level of cardio-respiratory fitness is inversely associated with the incidence of overweight and obesity in children and adolescents.[58]

A valid and reliable test battery—the ALPHA (Assessing Levels of PHysical Activity) health-related fitness test battery for children and adolescents— has been developed.[57,59] In this test battery, 2 tests are proposed for the assessment of endurance capacity: a 20-m shuttle run test and a 1.6-km (1-mile) walk/jog test. The 20-m shuttle run test is more reliable and valid for estimating peak oxygen uptake ($\dot{V}o_2$peak) and is more feasible for young people than the 1.6-km (1-mile) walk/jog test; therefore, the 20-m shuttle run test is preferred.[59]

In the 20-m shuttle run test, a participant runs back and forth in both directions on a 20-m track marked between 2 separate lines. The rhythm is set by means of audio signals. The initial speed is set at 8.5 km/h, and the speed is increased by 0.5 km/h every minute. A participant should step behind the 20-m line exactly when he or she hears the audio signal. The test is finished when the participant stops because of fatigue or fails to reach the end line concurrent with the audio signal on 2 consecutive occasions. Aerobic performance is expressed by the number of times a participant completes the 20-m track. Physical therapists are advised to compare outcomes with reference values from their home countries and to observe the percentile score for endurance exercise capacity.

In adolescents with obesity, the $\dot{V}o_2$peak (as measured by ergospirometry) before and after exercise interventions correlates well with the outcome of the 20-m shuttle run test ($r=.80$–$.83$) before and after exercise interventions.[60] In addition, there is an age- and sex-independent correlation between the outcome of the 20-m shuttle run test and the waist circumference ($r=-.50$, $P<.05$) in children and adolescents.[61] Therefore, it may be anticipated that the 20-m shuttle run test score will be significantly lower in children and adolescents with obesity than in children and adolescents without obesity.[62] Although this test has been proven to be safe, it should be stopped in case of excessive dyspnea, skin pallor, or dizziness.[57] A disadvantage of the 20-m shuttle run test is the need for a sufficiently long corridor or hall. However, considering the high validity

of this test in children and adolescents with obesity, physical therapists are advised to seek such infrastructure.

In conclusion, for the evaluation of endurance capacity (prediction of $\dot{V}o_2$peak) in children and adolescents with obesity, the 20-m shuttle run test is recommended. Physical therapists are advised to assess and report changes in percentile scores for endurance exercise capacity.

Muscle strength (level of evidence: 2++; grade of recommendation: B). Muscle strength tests can be used to screen for muscle weakness or muscle strength imbalance. Muscle strength is an important component of motor skill performance; therefore, a valid assessment of muscle strength is recommended for all patients.

In the ALPHA health-related fitness test battery, the handgrip strength test is recommended for the assessment of muscle strength in children and adolescents.[57,59] The child or adolescent executes the test in the standing position with the arm extended downward, and the grip span is adjusted according to the patient's hand size. Next, the child or adolescent squeezes as hard as possible for 3 seconds. The test is executed 2 times with both hands. An average score is then calculated for both hands. Consultation of national reference values can indicate whether handgrip strength is normal. In the presence of an acute or chronic injury of the arm or hand, the handgrip strength test is no longer valid for estimating whole-body muscle strength.[63] In children and adolescents with obesity, it was observed that handgrip strength (as well as knee extension strength) increased with a higher BMI.[64] On the other hand, children and adolescents with obesity often performed poorly in strength tests that involved the child's own body weight (such as pull-ups).[64]

Another strength test that is recommended for children and adolescents is the standing broad jump test for the assessment of lower limb explosive muscle strength.[63] From a starting position immediately behind a line and standing with feet approximately shoulder width

apart, the child or adolescent jumps as far as possible with the feet together. During this jump, motion of the arms is allowed. A nonslip hard surface, chalk, and a tape measure are needed to perform the test. The result is recorded in centimeters.[63] Physical therapists can then determine whether the jump distance is in accordance with a normal percentile score. Children and adolescents with obesity performed significantly worse during the standing broad jump test than their counterparts without obesity.[65]

In conclusion, the handgrip strength test and the standing broad jump test seem to be valid and reliable field muscle strength tests for children and adolescents with obesity. However, test outcomes will be significantly different when a handgrip strength test and a standing broad jump test are used in children and adolescents with obesity. Therefore, the use of both tests is recommended. Physical therapists are advised to assess and report changes in percentile scores for muscle strength.

Impact and Content of Physical Activity Recommendations for Children and Adolescents With Obesity

Impact of Exercise Training or Increase in Physical Activity in Children and Adolescents With Obesity

Meta-analyses have provided systemic support for the notion that the impact of structured regular exercise training (endurance training, strength training, or both) or increased physical activity, without dietary cointervention, in children and adolescents with obesity contributes to improved insulin sensitivity (Hedges g effect size=0.31) and glycemic control (reduction of fasting insulin level; Hedges g effect size=0.48),[66] muscle strength (standardized mean difference=0.63),[67] and systolic blood pressure (mean effect size=-0.46)[40] and has a moderate positive effect on endurance exercise capacity.[68] Exercise training thus leads to improvements in many health parameters. Unfortunately, most children with obesity and their parents

tend to focus on changes in body weight only. Regular exercise training contributes to a significant decrease in the percentage of body fat in children and adolescents with obesity.[69-71] However, a reduction in body weight as a result of exercise is not always noticed (probably because of the augmentation of lean tissue mass).[69] This result signifies the need for discrimination between fat mass and fat-free mass in an evaluation of the impact of exercise training. The implementation of exercise training or increased physical activity for the treatment of obesity in children and adolescents should be part of a multidisciplinary program. The greatest therapeutic effectiveness is achieved and a broader range of health parameters is affected when multiple health care disciplines (physician, dietitian, psychologist, and physical therapist) are involved in the care of children and adolescents with obesity.

Exercise Prescription (Level of Evidence: 1+; Grade of Recommendation: A)

Increased physical activity and fitness in children and adolescents with obesity should be achieved primarily by promoting endurance exercises through participation in organized sports activities or daily life activities.[11,12] In this regard, practice-based exercise interventions can be set up by physical therapists, along with outdoor physical activity promotion, to maximize the likelihood of optimal body weight control. Furthermore, it is important to promote even small amounts of moderately to vigorously intense endurance activities as much as possible and to reduce sedentary activities (television, computer, and media time) to a maximum of 2 hours per day. Children younger than 2 years should not be allowed to watch television. The recommended level of activity (unstructured fun activity) is a minimum of 1 hour per day. This hour can be accumulated throughout the day. Sometimes spreading this exercise time over the day makes it easier, more feasible, and more enjoyable for children. Activities that involve parents or friends should be promoted to increase exercise therapy adherence, and enjoyable and fun activities should be executed during

practice-based exercise interventions as well.

The management of obesity in children and adolescents is a long-term process that must be sustained. To further support this process, children and adolescents with obesity and their families should be encouraged to maintain small changes for long periods. These seemingly small modifications can be highly beneficial in the long term. Physical therapists are encouraged to stay in contact with children and adolescents with obesity and their parents (especially after practice-based exercise interventions) to further promote physical activity and provide feedback or assistance when necessary.

The use of a staging model to prescribe exercise to children and adolescents with obesity has been proposed.[12] Users are advised to start at the lowest stage and gradually increase the stage of care as needed to reduce fat mass a sufficient amount within a certain time frame (Appendix 2). In this stage-dependent treatment of obesity in children and adolescents, physical therapists working in private and home care settings should be consulted in stages 2 and 3.

An individual prescription should be provided for children and adolescents with obesity in the presence of comorbidities, altered physiological responses to exercise, or both. To adhere to this recommendation, physical therapists should execute a thorough preparticipation screening (as described earlier). Alterations in training modalities are instrumental for greater fat mass reduction in children and adolescents with obesity. Even though general recommendations advocate an increase in the physical activity level, a greater endurance exercise volume generates a greater loss of fat mass (level of evidence: 1+; grade of recommendation: A).[70] In this regard, proper selection of training modalities (instead of increased physical activity only) is mandatory. For the generation of a greater endurance exercise volume, whole-body exercises involving large muscle groups (eliciting a greater caloric expenditure per time unit) are preferred, and prolonged exercise or physical activ-

ity (>1 hour) should be attempted. Physical therapists should carefully select whole-body exercises that are feasible, effective in terms of caloric expenditure, and pleasant for children and adolescents with obesity.

Although children and adolescents with obesity generally have similar or increased absolute muscle strength (ie, their strength per kilogram of fat-free mass is normal) relative to those without obesity,[71] strength training is indicated in case of muscle weakness. The fear that strength training will injure growth plates in children and adolescents is not supported by scientific evidence.[72] Strength training leads to a reduction in orthopedic injury incidence when children and adolescents follow an endurance training program.[72] Therefore, strength training exercises should be incorporated into exercise programs for children and adolescents with obesity (level of evidence: 1+, grade of recommendation: A). However, strength training should be prescribed to children and adolescents with obesity by a qualified health care professional only (including physical therapists), the exercises should be supervised to guarantee proper execution, and certain or specific devices (that are available in private physical therapy practices) sometimes are required.[72] In this regard, physical therapists can take responsibility for making such exercises feasible and safe for children and adolescents with obesity.

When the availability of strengthening devices is limited, exercises with a child's own body weight can be executed. Strength training can be started from the age of 5 years, although a child must be able to understand the directions and be willing to cooperate.[72] Child-size equipment should be selected, and large muscle groups should be targeted. It is important for children and adolescents to learn to execute a movement in the correct manner. For children and adolescents who are untrained and sedentary, physical therapists are advised to start at 1 or 2 series with a limited number of contractions (<5) at 60% of the 1-repetition maximum.[72] In this way, children and adolescents can first learn how to properly execute the movement,

and then the physical therapist can progress to the following strength training modalities: 2 to 4 sets per muscle group, 6 to 12 repetitions at less than 80% of the 1-repetition maximum, and rest intervals of 1 to 3 minutes.[72] Contraction velocity will be slow at the beginning but may increase as the movement is properly executed.[72] Strength training exercises should be performed 2 or 3 times per week.[72] In children and adolescents, measuring the 1-repetition maximum directly is allowed.[72] Children and adolescents should be advised to remain physically active during the rest of the day and to avoid additional caloric intake after exercises. These guidelines are especially important after swimming or prolonged exercises because reduced satiety levels are sometimes observed.

In conclusion, a sufficient volume of exercise (including endurance and resistance exercises) should be promoted in children and adolescents who have obesity with the aim of reducing fat mass and improving health. Exercises should be appealing and pleasant for children and adolescents and should be prescribed and supervised by educated health care professionals.

Nutrition

For maximizing fat mass loss in children and adolescents with obesity and for improving the cardiovascular risk profile (such as blood high-density lipoprotein cholesterol, glucose, and insulin levels), exercise training or increased physical activity should be combined with dietary intervention.[73] However, adaptations in nutrition for children and adolescents with the aim of achieving normal fat mass and body weight are dependent not only on the severity of adiposity but also on age and maturation stage, and sometimes comorbidities (such as diabetes) have to be taken into account. Because of these difficulties, we strongly advise physical therapists to collaborate with a dietitian, even when only advising healthy nutrition. Physical therapists have a responsibility to collaborate with dietitians.

Exercise Physiology in Children and Adolescents With Obesity

The ventilatory, cardiovascular, and metabolic responses to exercise can be different in children and adolescents with obesity (Tab. 2). In contrast to a widely held belief, peak cycling power output and whole-body oxygen uptake capacity are not reduced in adolescents with obesity.[74] However, a reduction in oxidative capacity is observed when muscle mass is taken into account.[74] It follows that muscle oxidative metabolism can be reduced in children and adolescents with obesity, but this reduction is not observed at the whole-body level because of a slightly elevated muscle mass.

Substrate selection during exercise is disturbed in children and adolescents with obesity; they can experience a suppressed lipolytic response to exercise, lower fat oxidation capacity, or both.[75-77] One study reported increased cardiac output during maximal exercise testing in adolescents with obesity,[78] and another study with similar participants reported elevated $\dot{V}o_2$peak/heart rate (oxygen pulse), a parameter that is used to estimate cardiac stroke volume.[79] It has been hypothesized that an elevated cardiac stroke volume is probably due to a greater oxygen need that results from a greater fat mass.[78] On the other hand, children and adolescents with obesity are more likely to experience chronotropic incompetence, which is defined as the inability of the heart rate to increase in accordance with increases in workload or exercise intensity.[80,81] This finding is clinically relevant because, to be able to determine exercise training intensity on the basis of heart rate, this parameter should be assessed first. Simple formulas, such as $220 - \text{age}$, from which a fraction is taken to define exercise intensity, therefore are not valid in children and adolescents with obesity. Moreover, the use of ratings of perceived exertion for the determination of exercise intensity may be complicated in children and adolescents with obesity because of a lack of motivation to exercise, often derived from difficulties in sports or exercise-related activity participation.[82] Children and adolescents with obesity are more likely to report

Table 2.
Potentially Present Anomalous Exercise Responses in Children and Adolescents With Obesity

Parameter or Item	Anomaly	Clinical Implication
Peak cycling power output	Not reduced in absolute value but reduced when divided by lean tissue mass	Reduced endurance exercise tolerance
Peak oxygen uptake	Not reduced in absolute value but reduced when divided by lean tissue mass	Reduced endurance exercise tolerance
Lipolysis (fat mobilization)	Suppressed	
Fat oxidation capacity	Suppressed	
Cardiac output	Increased	
Cardiac stroke volume	Increased	
Peak exercise heart rate	Decreased (leading to chronotropic incompetence)	Invalid prediction equations for estimation of exercise heart rate
Blood pressure	Hypertensive response may be present	
Ratings of perceived exertion	Elevated at low- to moderate-intensity physical activities, especially weight-bearing activities	Potential for significantly different ratings of perceived exertion for weight-bearing vs non–weight-bearing exercises
Ventilatory function	Equivocal findings in literature	
Musculoskeletal discomfort	Provoked during weight-bearing exercise (test)	During weight-bearing exercises, symptoms of musculoskeletal discomfort should be addressed

higher ratings of perceived exertion at similar relative physiological exercise intensities.

Ventilatory responses during maximal endurance exercise testing in adolescents with obesity versus adolescents without obesity were examined only in 2 studies.[79,83] Respiratory rate, tidal volume, ventilatory equivalent for carbon dioxide output, and end-tidal partial carbon dioxide pressure were not different in the 2 groups,[83] whereas data on the ventilatory equivalent for oxygen (indicating the efficiency of ventilatory oxygen uptake) and minute ventilation during peak exercise were different in the 2 studies.[79,83] Children and adolescents with obesity are more likely to have musculoskeletal pain, especially during exercise.[16,17] These symptoms can be provoked by body-weight–carrying exercises, such as walking and running, and may be provoked less during exercises in which body weight is partly supported, such as cycling and swimming. It follows that exercise tolerance can deviate according to the type of exercise that is being executed.

The above-mentioned anomalies are more likely to occur in children and adolescents with a higher BMI or when the state of obesity is longer present. There-fore, physical therapists should adapt exercise prescriptions accordingly.

Maximizing Exercise Therapy Adherence and Chances for Continued Elevated Physical Activity in Children and Adolescents With Obesity

The clinical benefits of exercise training or increased physical activity will emerge only if such a program is also monitored for a sufficient period. Therefore, it is important for physical therapists to be aware of certain factors, actions, or adaptations that can be instrumental in the achievement of this goal (level of evidence: 3; grade of recommendation: D).

In the preparticipation screening, physical therapists should investigate potential internal and external barriers to the initiation or continuation of exercise training or increased physical activity. Physical therapists should, as far as they are able, try to partly address such issues. However, referral to a psychologist may be indicated when such barriers (especially internal barriers) remain present and significantly affect therapy adherence. A key regulator in changes in behavior, such as physical activity, in children and adolescents is self-efficacy.

Lower levels of self-efficacy are associated not only with less physical activity but also with a reduced ability to increase physical activity.[84] Therefore, along with prescribing exercise, physical therapists should try to enhance self-efficacy in children and adolescents with obesity. This aim can be achieved by creating a stimulating and fun environment, by setting realistic goals and taking small steps toward these goals (with positive attention and compliments for children and adolescents when the goals are achieved), and by avoiding negative attention when the goals are not achieved. This approach will lead children and adolescents to believe that they can be physically active and achieve certain physical abilities.

Prescribing exercises that are fun, enjoyable, varied, and not too difficult can be instrumental in further improving exercise adherence in children and adolescents with obesity.[85,86] Moreover, environmental factors and resources should be taken into account or improved when exercises are prescribed.[41,42] Group exercise training with peers could lead to enhanced motivation to exercise. Cooperation with parents or legal guardians of children and adolescents is very important; physical therapists should explain why exercise training is benefi-

cial for children, and parents or legal guardians should be supportive of their children and should realize that they are key role models for their children.[85] It follows that parents should adhere to a healthy lifestyle themselves to increase the chance for prolonged participation of their children in exercise interventions. Parents or legal guardians and physical therapists should participate in the prescribed exercises; this approach very likely will lead to increased cooperation of children and adolescents. Finally, it is important to regularly provide feedback on observed improvements in health parameters, especially when reductions in body weight are smaller than expected. In this way, children, adolescents, and parents will realize that exercise interventions can be highly effective in improving general health, regardless of changes in body weight.

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References

1 Ogden C, Carroll M. NCHS Health E-Stat: prevalence of obesity among children and adolescents—United States, trends 1963–1965 through 2007–2008. Publications and Information Products. Available at: http://www.cdc.gov/nchs/data/hestat/obesity_child_07_08/obesity_child_07_08.htm. Updated 2010. Accessed September 2014.

2 van Stralen MM, te Velde SJ, van Nassau F, et al. Status of European preschool children and associations with family demographics and energy balance-related behaviours: a pooled analysis of six European studies. *Obes Rev.* 2012;13:S29–S41.

3 World Health Organization. Global strategy on diet, physical activity and health: childhood overweight and obesity. Available at: http://www.who.int/dietphysicalactivity/childhood/en/. Accessed September 2014.

4 Neef M, Weise S, Adler M, et al. Health impact in children and adolescents. *Best Pract Res Clin Endocrinol Metab.* 2013; 27:229–238.

5 Ebbeling CB, Pawlak DB, Ludwig DS. Childhood obesity: public-health crisis, common sense cure. *Lancet.* 2002;360: 473–482.

6 Bruyndonckx L, Hoymans VY, Van Craenenbroeck AH, et al. Assessment of endothelial dysfunction in childhood obesity and clinical use. *Oxid Med Cell Longev.* 2013;2013:174782.

7 Han JC, Lawlor DA, Kimm SYS. Chilhood obesity. *Lancet.* 2010;375:1737–1748.

8 Zeller MH, Inge TH, Modi AC, et al. Severe obesity and comorbid condition impact on the weight-related quality of life of the adolescent patient. *J Pediatr.* 2015;166: 651–659.

9 Marder WD, Chang S. Childhood obesity: costs, treatment patterns, disparities in care, and prevalent medical conditions. Thomson Medstat Research Brief. Available at: http://www.medstat.com/pdfs/childhood_obesity.pdf. 2005. Accessed September 2014.

10 Batscheider A, Rzehak P, Teuner CM, et al. Development of BMI values of German children and their healthcare costs. *Econ Hum Biol.* 2014;12:56–66.

11 Baker JL, Farpour-Lambert NJ, Nowickac P, et al. Evaluation of the overweight/obese child: practical tips for the primary health care provider—recommendations from the Childhood Obesity Task Force of the European Association for the Study of Obesity. *Obes Facts.* 2010;3:131–137.

12 Barlow SE; Expert Committee. Expert committee recommendations regarding the prevention, assessment, and treatment of child and adolescent overweight and obesity: summary report. *Pediatrics.* 2007; 120:S164–S192.

13 Copeland KC, Silverstein J, Moore KR, et al. Management of newly diagnosed type 2 diabetes mellitus (T2DM) in children and adolescents. *Pediatrics.* 2013; 131;364–382.

14 van Vliet M, Heymans MW, von Rosenstiel IA, et al. Cardiometabolic risk variables in overweight and obese children: a worldwide comparison. *Cardiovasc Diabetol.* 2011;10:106.

15 Fiorino EK, Brooks LJ. Obesity and respiratory diseases in childhood. *Clin Chest Med.* 2009;30:601–608.

16 Paulis WD, Silva S, Koes BW, et al. Overweight and obesity are associated with musculoskeletal complaints as early as childhood: a systematic review. *Obes Rev.* 2014;15:52–67.

17 Krul M, van der Wouden JC, Schellevis FG, et al. Musculoskeletal problems in overweight and obese children. *Ann Fam Med.* 2009;7:352–356.

18 Abeysekara P, Turchi R, O'Neil M. Obesity and children with special healthcare needs: special considerations for a special population. *Curr Opin Pediatr.* 2014;26: 508–515.

19 Schlessman AM, Martin K, Ritzline PD, et al. The role of physical therapists in pediatric health promotion and obesity prevention: comparison of attitudes. *Pediatr Phys Ther.* 2011;23:79–86.

20 He M, Piché L, Clarson CL, et al. Childhood overweight and obesity management: a national perspective of primary health care providers' views, practices, perceived barriers and needs. *Paediatr Child Health.* 2010;15:419–426.

21 Harbour R, Miller J. A new system for grading recommendations in evidence based guidelines. *BMJ.* 2001;323:334–336.

22 Cole TJ, Lobstein T. Extended international (IOTF) body mass index cut-offs for thinness, overweight and obesity. *Pediatr Obes.* 2012;7:284–294.

23 Centers for Disease Control & Prevention. Defining childhood obesity: BMI for children and teens. Division of Nutrition, Physical Activity, and Obesity. Available at: http://www.cdc.gov/obesity/childhood/defining.html. Accessed June 2015.

24 Kuczmarski RJ, Ogden CL, Guo SS, et al. 2000 CDC growth charts for the United States: methods and development. *Vital Health Stat 11.* 2002;246:1–190.

25 Liu A, Byrne NM, Kagawa M, et al. Ethnic differences in the relationship between body mass index and percentage body fat among Asian children from different backgrounds. *Br J Nutr.* 2011;106:1390–1397.

26 Reilly JJ, Kelly J, Wilson DC. Accuracy of simple clinical and epidemiological definitions of childhood obesity: systematic review and evidence appraisal. *Obes Rev.* 2010;11:645–655.

27 Freedman DS, Sherry B. The validity of BMI as an indicator of body fatness and risk among children. *Pediatrics.* 2009;124:S23–S34.

28 Kâ K, Rousseau MC, Lambert M, et al. Association between lean and fat mass and indicators of bone health in prepubertal Caucasian children. *Horm Res Paediatr.* 2013;80:154–162.

29 Kuhle S, Fung C, Veugelers PJ. Medication use in normal weight and overweight children in a nationally representative sample of Canadian children. *Arch Dis Child.* 2012;97:842–847.

30 Sherafat-Kazemzadeh R, Yanovski SZ, Yanovski JA. Pharmacotherapy for childhood obesity: present and future prospects. *Int J Obes.* 2013;37:1–15.

31 Springer SC, Silverstein J, Copeland K, et al. Management of type 2 diabetes mellitus in children and adolescents. *Pediatrics.* 2013;131:e648–e664.

32 Hansen D, Peeters S, Zwaenepoel B, et al. Exercise assessment and prescription in patients with type 2 diabetes in the private and home care setting: clinical recommendations from AXXON (Belgian Physical Therapy Association). *Phys Ther.* 2013;93:597–610.

33 Kwok SY, So HK, Choi KC, et al. Resting heart rate in children and adolescents: association with blood pressure, exercise and obesity. *Arch Dis Child.* 2013;98:287–291.

34 DuBose KD, Cummings DM, Imai S, et al. Development and validation of a tool for assessing glucose impairment in adolescents. *Prev Chronic Dis.* 2012;9:E104.

35 Freitas Júnior IF, Monteiro PA, Silveira LS, et al. Resting heart rate as a predictor of metabolic dysfunctions in obese children and adolescents. *BMC Pediatr.* 2012;12:5.

36 Fleming S, Thompson M, Stevens S, et al. Normal ranges of heart rate and respiratory rate in children from birth to 18 years: a systematic review of observational studies. *Lancet.* 2011;377:1011–1018.

37 Pickering TG, Hall JE, Appel LJ, et al. Recommendations for blood pressure measurement in humans and experimental animals, part 1: blood pressure measurement in humans—a statement for professionals from the Subcommittee of Professional and Public Education of the American Heart Association Council on High Blood Pressure Research. *Circulation.* 2005;111:697–716.

38 Flynn JT, Daniels SR, Hayman LL, et al. Update: ambulatory blood pressure monitoring in children and adolescents—a scientific statement from the American Heart Association. *Hypertension.* 2014;63:1116–1135.

39 Mellerio H, Alberti C, Druet C, et al. Novel modeling of reference values of cardiovascular risk factors in children aged 7 to 20 years. *Pediatrics.* 2012;129:e1020–e1029.

40 García-Hermoso A, Saavedra JM, Escalante Y. Effects of exercise on resting blood pressure in obese children: a meta-analysis of randomized controlled trials. *Obes Rev.* 2013;14:919–928.

41 Stankov I, Olds T, Cargo M. Overweight and obese adolescents: what turns them off physical activity? *Int J Behav Nutr Phys Act.* 2012;9:53.

42 Bauman AE, Reis RS, Sallis JF, et al. Correlates of physical activity: why are some people physically active and others not? *Lancet.* 2012;380:258–271.

43 Vissers D, Devoogdt N, Gebruers N, et al. Overweight in adolescents: differences per type of education—does one size fit all? *J Nutr Educ Behav.* 2008;40:65–71.

44 Ellery CV, Weiler HA, Hazell TJ. Physical activity assessment tools for use in overweight and obese children. *Int J Obes.* 2014;38:1–10.

45 Chinapaw MJ, Mokkink LB, van Poppel MN, et al. Physical activity questionnaires for youth: a systematic review of measurement properties. *Sports Med.* 2010;40:539–563.

46 Mitre N, Lanningham-Foster L, Foster R, et al. Pedometer accuracy for children: can we recommend them for our obese population? *Pediatrics.* 2009;123:e127–e131.

47 Huang L, Chen P, Zhuang J, et al. Metabolic cost, mechanical work, and efficiency during normal walking in obese and normal-weight children. *Res Q Exerc Sport.* 2013;84:S72–S79.

48 McCarthy DH. Measuring growth and obesity across childhood and adolescence. *Proc Nutr Soc.* 2014;73:210–217.

49 Wells JC, Fewtrell MS. Is body composition important for paediatricians? *Arch Dis Child.* 2008;93:168–172.

50 Lohman TG, Going SB. Body composition assessment for development of an international growth standard for preadolescent and adolescent children. *Food Nutr Bull.* 2006;27:S314–S325.

51 Watts K, Naylor LH, Davis EA, et al. Do skinfolds accurately assess changes in body fat in obese children and adolescents? *Med Sci Sports Exerc.* 2006;38:439–444.

52 Wells JCK, Fewtrell MS. Measuring body composition. *Arch Dis Child.* 2006;91:612–617.

53 Lara M, Bustos P, Amigo H, et al. Is waist circumference a better predictor of blood pressure, insulin resistance and blood lipids than body mass index in young Chilean adults? *BMC Public Health.* 2012;12:638.

54 International Diabetes Federation. The IDF consensus definition of the metabolic syndrome in children and adolescents. Available at: https://www.idf.org/webdata/docs/Mets_definition_children.pdf. 2007. Accessed June 2015.

55 Ness-Abramof R, Apovian CM. Waist circumference measurement in clinical practice. *Nutr Clin Pract.* 2008;23:397–404.

56 Talma H, Chinapaw MJM, Bakker B, et al. Bioelectrical impedance analysis to estimate body composition in children and adolescents: a systematic review and evidence appraisal of validity, responsiveness, reliability and measurement error. *Obes Rev.* 2013;14:1–11.

57 Ruiz JR, Castro-Piñero J, España-Romero V, et al. Field-based fitness assessment in young people: the ALPHA health-related fitness test battery for children and adolescents. *Br J Sports Med.* 2011;45:518–524.

58 Savva SC, Tornaritis MJ, Kolokotroni O, et al. High cardiorespiratory fitness is inversely associated with incidence of overweight in adolescence: a longitudinal study. *Scand J Med Sci Sports.* 2014;24:982–989.

59 Castro-Piñero J, Artero EG, España-Romero V, et al. Criterion-related validity of field-based fitness tests in youth: a systematic review. *Br J Sports Med.* 2010;44:934–943.

60 Quinart S, Mougin F, Simon-Rigaud ML, et al. Evaluation of cardiorespiratory fitness using three field tests in obese adolescents: validity, sensitivity and prediction of peak $\dot{V}o_2$. *J Sci Med Sport.* 2014;17:521–525.

61 Silva G, Aires L, Martins C, et al. Cardiorespiratory fitness associates with metabolic risk independent of central adiposity. *Int J Sports Med.* 2013;34:912–916.

62 Galavíz KI, Tremblay MS, Colley R, et al. Associations between physical activity, cardiorespiratory fitness, and obesity in Mexican children. *Salud Publica Mex.* 2012;54:463–469.

63 Ortega FB, Artero EG, Ruiz JR, et al. Reliability of health-related physical fitness tests in European adolescents: the HELENA Study. *Int J Obes.* 2008;32:S49–S57.

64 Ervin RB, Fryar CD, Wang CY, et al. Strength and body weight in US children and adolescents. *Pediatrics.* 2014;134:e782–e789.

65 Deforche B, Lefevre J, De Bourdeaudhuij I, et al. Physical fitness and physical activity in obese and nonobese Flemish youth. *Obes Res.* 2003;11:434–441.

66 Fedewa MV, Gist NH, Evans EM, et al. Exercise and insulin resistance in youth: a meta-analysis. *Pediatrics.* 2014;133:e163–e174.

67 Schranz N, Tomkinson G, Olds T. What is the effect of resistance training on the strength, body composition and psychosocial status of overweight and obese children and adolescents? A systematic review and meta-analysis. *Sports Med.* 2013;43: 893–907.

68 Saavedra JM, Escalante Y, Garcia-Hermoso A. Improvement of aerobic fitness in obese children: a meta-analysis. *Int J Pediatr Obes.* 2011;6:169–177.

69 Kelley GA, Kelley KS. Effects of exercise in the treatment of overweight and obese children and adolescents: a systematic review of meta-analyses. *J Obes.* 2013; 2013:783103.

70 Atlantis E, Barnes EH, Singh MA. Efficacy of exercise for treating overweight in children and adolescents: a systematic review. *Int J Obes.* 2006;30:1027–1040.

71 Tsiros MD, Coates AM, Howe PRC, et al. Obesity: the new childhood disability? *Obes Rev.* 2010;12:26–36.

72 Lloyd RS, Faigenbaum AD, Stone MH, et al. Position statement on youth resistance training: the 2014 International Consensus. *Br J Sports Med.* 2014;48:498–505.

73 Ho M, Garnett SP, Baur LA, et al. Impact of dietary and exercise interventions on weight change and metabolic outcomes in obese children and adolescents: a systematic review and meta-analysis of randomized trials. *JAMA Pediatr.* 2013;167:759–768.

74 Hansen D, Marinus N, Remans M, et al. Exercise tolerance in obese vs. lean adolescents: a systematic review and meta-analysis. *Obes Rev.* 2014;15:894–904.

75 Lazzer S, Busti C, Agosti F, et al. Optimizing fat oxidation through exercise in severely obese caucasian adolescents. *Clin Endocrinol.* 2007;67:582–588.

76 McMurray RG, Hosick PA. The interaction of obesity and puberty on substrate utilization during exercise: a gender comparison. *Pediatr Exerc Sci.* 2011;23:411–431.

77 Zunquin G, Theunynck D, Sesboüé B, et al. Comparison of fat oxidation during exercise in lean and obese pubertal boys: clinical implications. *Br J Sports Med.* 2009;43:869–870.

78 Ingul CB, Tjonna AE, Stolen TO, et al. Impaired cardiac function among obese adolescents: effect of aerobic interval training. *Arch Pediatr Adolesc Med.* 2010; 164:852–859.

79 Rowland TW. Effects of obesity on aerobic fitness in adolescent females. *Am J Dis Child.* 1991;145:764–768.

80 Drinkard B, Roberts MD, Ranzenhofer LM, et al. Oxygen-uptake efficiency slope as a determinant of fitness in overweight adolescents. *Med Sci Sports Exerc.* 2007;39: 1811–1816.

81 Norman AC, Drinkard B, McDuffie JR, et al. Influence of excess adiposity on exercise fitness and performance in overweight children and adolescents. *Pediatrics.* 2005;115:e690–e696.

82 Owens S, Gutin B. Exercise testing of the child with obesity. *Pediatr Cardiol.* 1999; 20:79–83.

83 Mendelson M, Michallet AS, Estève F, et al. Ventilatory responses to exercise training in obese adolescents. *Respir Physiol Neurobiol.* 2012;184:73–79.

84 Craggs C, Corder K, van Sluijs EM, et al. Determinants of change in physical activity in children and adolescents: a systematic review. *Am J Prev Med.* 2011;40:645–658.

85 Floriani V, Kennedy C. Promotion of physical activity in primary care for obesity treatment/prevention in children. *Curr Opin Pediatr.* 2007;19:99–103.

86 Alberga AS, Medd ER, Adamo KB, et al. Top 10 practical lessons learned from physical activity interventions in overweight and obese children and adolescents. *Appl Physiol Nutr Metab.* 2013;38:249–258.

Appendix 1.
Methods and Steps in the Selection of Preparticipation Tests for Children and Adolescents With Obesity

Characteristics and Working Process of AXXON

All members were graduate physical therapists and participated in all group discussions and meetings. Four colleagues were active in a private physical therapy setting (S.P., C.W., S.V.U., and D. Verleyen), 1 colleague was a PhD student (W.H.), and 2 colleagues were associate professors at a Flemish university (D.H. and D. Vissers). No other stakeholders participated.

After a careful literature search, consensus was always reached by the group after one or more meetings. In this consensus process, there was no influence of the sponsorship by AXXON.

Step 1: Selection of Preparticipation Tests in Private and Home Care Physical Therapy Settings Only for Children and Adolescents with Obesity

Handled criteria: tests should be feasible in these settings; tests should be valid in these patients

The result of the first AXXON group discussion was that the following items should be assessed in the preparticipation screening of children and adolescents with obesity: medical safety, physical activity, body composition, endurance exercise capacity, muscle strength, and internal and external barriers to exercise participation.

Step 2: Search for Preparticipation Tests in Literature

PubMed was consulted up to October 2014 for the examination of the validity and reliability of certain tests only for children and adolescents with obesity (<19 years old).

- Preferentially recent (published after 2005) position statements, meta-analyses, and systematic reviews were searched.
- In case of a lack of these types of publications, experimental studies (cross-sectional studies and randomized controlled trials) were searched.

For assessment of the medical safety of exercise, current literature in which rates of prevalence of comorbidities and medication intake in children and adolescents with obesity were reported was consulted.

(Continued)

Appendix 1.
Continued

For physical activity assessment, the following methods were examined: questionnaires, pedometers, load transducers, heart rate monitors, multiple-sensor systems, global positioning systems, and accelerometers.

For body composition assessment, the following methods were examined: bioelectrical impedance analysis, waist circumference, skinfold thickness, and body mass index.

For endurance exercise capacity assessment, the following methods were examined: various shuttle run tests, various limited-distance run or walk tests, various limited-time run or walk tests, and 1-minute jump rope test.

For muscle strength assessment, the following methods were examined: handgrip strength, trunk lift, various endurance strength tests, and various explosive strength tests.

For the assessment of internal and external barriers to exercise participation, literature in which these barriers in children and adolescents with obesity were examined was consulted.

Step 3: Final Selection of Preparticipation Tests

A discussion of the outcomes of the techniques and methods used for preparticipation screening in the literature took place in the second AXXON group meeting. Further detailed examination of the literature was executed after this discussion.

A final consensus about which tests should be used in the preparticipation screening of children and adolescents with obesity was reached in the third AXXON group meeting.

Appendix 2.
Recommendations for Preparticipation Screening and Increasing Physical Activity or Exercise Training for Children and Adolescents With Obesity

Step 1: Execute Preparticipation Screening

Medical Safety
- Check medical history, ask about current symptoms and limitations, and record medication intake
- Check for respiratory anomalies, orthopedic injuries and limitations, and psychosocial difficulties
- Examine cardiovascular system: blood pressure and heart rate
- Examine respiratory system: ventilatory limitation, atelectasis
- Examine orthopedic system
- Check for internal and external barriers to exercise training
- Refer patient (back) to physician in case of untreated or previously unknown hypertension, severely disabling or limiting orthopedic anomalies, severely disabling or limiting pulmonary dysfunction, or significant internal barriers to exercise participation that can lead to premature dropping out and cannot be affected by a physical therapist

Physical Activity
- Accelerometry for at least 3 consecutive days

Weight Status
- Body mass index should be used only to diagnose obesity at entry into an intervention

Body Composition
- Medical imaging techniques (such as dual-energy x-ray absorptiometry and magnetic resonance imaging) should be used to assess body composition at entry into an intervention; waist circumference should be measured to assess changes in adipose tissue mass during follow-up (changes in percentile scores should be measured and reported during follow-up)

Physical Fitness
- Endurance exercise capacity should be examined with the 20-m shuttle run test (changes in percentile scores should be measured and reported during follow-up)

(Continued)

Appendix 2.
Continued

- Muscle strength should be examined with handgrip strength and standing broad jump tests (changes in percentile scores should be measured and reported during follow-up)

Step 2: Apply General and Additional Exercise Training or Physical Activity Recommendations

American Academy of Pediatrics Staging System

- Stage 1
  - ° Minimize television viewing and computer time: <2 h/d
  - ° Unstructured fun endurance activities: >1 h/d
- Stage 2
  - ° Minimize television viewing and computer time: <1 h/d
  - ° Planned endurance activities: >1 h/d (under coordination of physical therapist)
- Stage 3
  - ° Minimize television viewing and computer time: <1 h/d
  - ° Structured exercise training under direct supervision of multidisciplinary team as often as possible
- Stage 4
  - ° High-volume exercise training, caloric intake restriction, and weight-reducing medication in specialized multidisciplinary center only

Additional Training Modality Adaptations and Precautions

- Maximize caloric expenditure during exercise training (prolonged exercise training, training types with high caloric expenditure per time unit)
- Add strength training exercises
- Maintain sufficient physical activity and prevent additional caloric intake
- Chronotropic incompetence, which complicates prescription of exercise intensity, may be present
- Use of ratings of perceived exertion to determine exercise intensity is not always valid

Step 3: Increase Medical Safety During Exercise Training

- Cardiopulmonary anomalies, metabolic anomalies, or both may be present during exercise; be aware of symptoms and clinical implications
- Orthopedic anomalies or pain can complicate prescription of exercise; be aware of symptoms and clinical implications

Step 4: Maximize Exercise Therapy Adherence

- Take observed factors and barriers from preparticipation screening into account
- Prescribe fun, low- to moderate-intensity, varied exercises
- Implement exercise training in appropriate environments and conditions
- Cooperate with parents or legal guardians
- Provide regular feedback on various parameters
- Parents or legal guardians and physical therapists should participate in exercises

Appendix 3.
Grading System for Recommendations in the Present Guideline[a]

Levels of Evidence

1++ High-quality meta-analyses, systematic reviews of RCTs, or RCTs with a very low risk of bias

1+ Well-conducted meta-analyses, systematic reviews of RCTs, or RCTs with a low risk of bias

1− Meta-analyses, systematic reviews or RCTs, or RCTs with a high risk of bias

2++ High-quality systematic reviews of case-control or cohort studies *or*

High-quality case-control or cohort studies with a very low risk of confounding, bias, or chance and a high probability that the relationship is causal

2+ Well-conducted case-control or cohort studies with a low risk of confounding, bias, or chance and a moderate probability that the relationship is causal

2− Case-control or cohort studies with a high risk of confounding, bias, or chance and a significant risk that the relationship is not causal

3 Nonanalytic studies (eg, case reports, case series)

4 Expert opinion

Grades of Recommendations

A At least one meta-analysis, systematic review, or RCT rated as 1++ and directly applicable to the target population *or*

A systematic review of RCTs or a body of evidence consisting principally of studies rated as 1+, directly applicable to the target population, and demonstrating overall consistency of results

B A body of evidence including studies rated as 2++, directly applicable to the target population, and demonstrating overall consistency of results *or*

Extrapolated evidence from studies rated as 1++ or 1+

C A body of evidence including studies rated as 2+, directly applicable to the target population, and demonstrating overall consistency of results *or*

Extrapolated evidence from studies rated as 2++

D Evidence level 3 or 4 *or*

Extrapolated evidence from studies rated as 2+

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[a] RCT=randomized controlled trial. Reprinted with permission from: Harbour R, Miller J. A new system for grading recommendations in evidence based guidelines. *BMJ*. 2001;323:334–336. Copyright 2001, BMJ Group.