Fitkids Treadmill Test: Age- and Sex-Related Normative Values in Dutch Children and Adolescents

Elles M.W. Kotte, Janke F. de Groot, Bart C. Bongers, Alexander M.F. Winkler, Tim Takken

Background. Recent research has shown that the Fitkids Treadmill Test (FTT) is a valid and reproducible exercise test for the assessment of aerobic exercise capacity in children and adolescents who are healthy.

Objective. The study objective was to provide sex- and age-related normative values for FTT performance in children and adolescents who were healthy, developing typically, and 6 to 18 years of age.

Design. This was a cross-sectional, observational study.

Methods. Three hundred fifty-six children and adolescents who were healthy (174 boys and 182 girls; mean age=12.9 years, SD=3.7) performed the FTT to their maximal effort to assess time to exhaustion (TTE). The least-mean-square method was used to generate sex- and age-related centile charts (P3, P10, P25, P50, P75, P90, and P97) for TTE on the FTT.

Results. In boys, the reference curve (P50) showed an almost linear increase in TTE with age, from 8.8 minutes at 6 years of age to 16.1 minutes at 18 years of age. In girls, the P50 values for TTE increased from 8.8 minutes at 6 years of age to 12.5 minutes at 18 years of age, with a plateau in TTE starting at approximately 10 years of age.

Limitations. Youth who were not white were underrepresented in this study.

Conclusions. This study describes sex- and age-related normative values for FTT performance in children and adolescents who were healthy, developing typically, and 6 to 18 years of age. These age- and sex-related normative values will increase the usefulness of the FTT in clinical practice.

E.M.W. Kotte, MSc, Fitkids Foundation, Box 75751, 1070 AT Amsterdam, the Netherlands. Address all correspondence to Ms Kotte at: elles@fitkids.nl.

J.F. de Groot, PhD, Utrecht University of Applied Sciences, Utrecht, the Netherlands; Child Development and Exercise Center, Wilhelmina Children's Hospital, University Medical Center Utrecht, Utrecht, the Netherlands; and Partner of Shared Utrecht Pediatric Exercise Research Lab, Utrecht, the Netherlands.

B.C. Bongers, PhD, Child Development and Exercise Center, Wilhelmina Children's Hospital, University Medical Center Utrecht; Partner of Shared Utrecht Pediatric Exercise Research Lab; and Department of Epidemiology, School for Public Health and Primary Care, Maastricht University, Maastricht, the Netherlands.

A.M.F. Winkler, MD, Fitkids Foundation.

T. Takken, PhD, Child Development and Exercise Center, Wilhelmina Children's Hospital, University Medical Center Utrecht, and Partner of Shared Utrecht Pediatric Exercise Research Lab.

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Exercise testing is being used with increasing frequency by pediatric physical therapists to assess the physical fitness of children and adolescents or to implement training programs.[1] Studies have shown that physical fitness is a powerful maker of health in youth.[2,3] With the use of cardiopulmonary exercise testing, therapists and exercise physiologists are able to determine peak oxygen uptake, which is the measure most commonly used for assessing aerobic fitness.[4,5] However, direct measurement of peak oxygen uptake requires sophisticated respiratory gas exchange equipment and specific training. Therefore, interest in methods in which aerobic fitness is estimated by use of predictive equations from functional outcomes during exercise tests is growing.[6]

Several valid and reliable strategies for estimating aerobic fitness in daily clinical practice by use of a cycle ergometer or treadmill are available.[7,8] Recently, our research group developed a new practical treadmill protocol for assessing aerobic fitness in children and adolescents: the Fitkids Treadmill Test (FTT). This development was based on a practical request articulated by physical therapists working with the Fitkids program. The FTT has 2 practical advantages over other established treadmill protocols. First, the protocol starts with a 0% incline, making it useful in children and adolescents with limited motor performance or those using an ankle-foot orthosis. Second, the maximal incline of the protocol is restricted to the maximal incline of standard treadmills, which is 15%, as these treadmills are most often available in outpatient physical therapy practices. A treadmill was chosen instead of a cycle ergometer because almost all children in the Fitkids program can be appropriately tested on a treadmill—even younger children (younger than 8 years), who have relatively underdeveloped knee extensor strength and do not fit on a standard cycle ergometer because of their short leg length.

The main outcome measure of the FTT is time to exhaustion (TTE), which is defined as the point at which a participant can no longer exercise against the speed and incline of the treadmill, despite strong verbal encouragement. In a recent study,[9] good validity and reproducibility of the FTT in healthy children and adolescents were reported. Aerobic fitness can be accurately predicted from FTT performance (TTE) and body mass in boys and girls who are healthy (R^2=.935).[9] At this point, sex- and age-related normative values for the FTT are lacking. Normative values will increase the usefulness of the FTT in clinical practice, as a physical therapist or exercise physiologist can determine whether a child's aerobic fitness is likely to be above average, average, or below average on the basis of FTT performance.

The aim of the present study was to provide normative values for TTE on the FTT in children and adolescents who were healthy, developing typically, and 6 to 18 years of age.

Method

Participants

Children and adolescents who were healthy and 6 to 18 years old were eligible to participate in this cross-sectional, observational study. The majority of the children and adolescents who were healthy were recruited from a primary school and several secondary schools, whereas a minority of the adolescents were recruited from local recreational sport clubs. At the schools, the selection procedure was based on class lists; only name and age were available.

Randomly selected participants were provided with an information package. The inclusion of participants started after approval of the Central Committee on Research Involving Human Subjects in the Netherlands. In total, 441 information packages were distributed to both the children and their parents. The modified Physical Activity Readiness Questionnaire was used to evaluate the health status of the children and adolescents who were willing to participate as well as to assess safety for performing maximal exercise. Exclusion criteria were a positive response to one or more questions on the modified Physical Activity Readiness Questionnaire, the use of medication affecting exercise capacity, cardiovascular or respiratory disease, musculoskeletal disease, metabolic disease, impaired motor development, or morbid obesity (body mass index [BMI] standard deviation score (SDS) >2.5).

To construct sex- and age-related normative values, we used the least mean squares method. It is not possible to perform a power calculation for setting up normative values with the least mean squares method. However, a minimum of 10 boys and 10 girls for each age seemed to be a feasible and sufficient number of participants for collecting and constructing generalizable and robust normative values. For the lowest and highest ages and within the age range of 12 to 14 years, we aimed to include 15 boys and 15 girls for an optimal fit of the data at both ends of the reference curve and because we expected a major development in exercise capacity due to puberty.

Informed consent was signed by both parents as well as by children 12 years old and older. Assent was obtained from children younger than 12 years of age.

Anthropometry

Before exercise testing, body mass, body height, and sitting height were determined to the nearest 0.5 kg and 0.1 cm with an analog scale (Medisana PSD, Medisana Benelux NV, Kerkrade, the Netherlands) and a stadiometer (Seca 213, Seca, Hamburg, Germany). For these measurements, participants were wearing light clothes and no shoes. The BMI was derived from body mass and body height, whereas leg length was calculated by subtracting sitting height from body height. Standard deviation scores were calculated for BMI for age with Dutch reference values.[10] Subcutaneous fat of the biceps, triceps, subscapular, and suprailiac skinfolds was measured with a Harpenden skinfold caliper (Baty International, West Sussex, United Kingdom). The sum of the average of 3 measures for each measurement site was used to estimate body density with the equations proposed by Deurenberg et al.[11] To estimate percent body fat and subsequently to calculate fat-free mass, we used the Siri equation.[12] Body surface area was calculated with the equation of

Haycock et al,[13] which has been validated in infants, children, and adults.

Physical Activity Levels and Sedentary Time

Physical activity levels and sedentary time were assessed with the Dutch Standard Physical Activity Questionnaire for Youth (Indicators for Monitoring Youth Health).[14] For children younger than 12 years of age, parents were asked how many days, in a typical week, their child walks or bikes to school, plays sports at school, plays sports at a sports club, and plays outside (outside school hours). In addition, the average duration of these activities on a typical day was assessed. Sedentary screen-based behavior was assessed in a similar manner, by asking parents about their child's television watching (including videos, DVDs, and YouTube) and computer playing. Children 12 years of age and older completed the questionnaire themselves.

Participants were categorized as "inactive" (<180 minutes of physical activity per week), "semi-inactive" (180–299 minutes of physical activity per week), "semi-active" (300–419 minutes of physical activity per week), or "normally active" (>420 minutes of moderate- to vigorous-intensity physical activity per week) according to the Dutch public health guidelines for recommended levels of physical activity for children and adolescents.[15]

FTT

Participants recruited from the primary and secondary schools were tested in a quiet room at their school, and the FTT was performed on a motor-driven treadmill ergometer (Lode Valiant, Lode BV, Groningen, the Netherlands). Adolescents recruited from sports clubs were tested at a local fitness center, and a calibrated treadmill ergometer at the fitness center was used. To ensure that the setup at the sports clubs was similar to that at the schools, we tested the participants mainly outside hours when the fitness center was open. When it was not possible to test the participants during these hours, we chose to position the treadmill ergometer out of sight of other athletes during testing. During testing, heart rate was monitored with a heart rate belt (Polar H1 transmitter, Polar, Kempele, Finland).

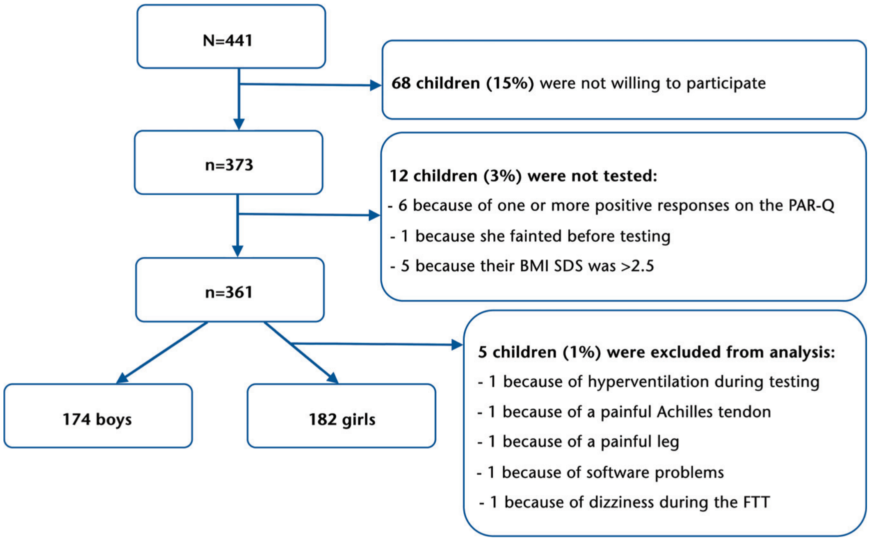

Figure 1.
Flowchart of the inclusion procedure. BMI=body mass index, FTT=Fitkids Treadmill Test, PAR-Q=Physical Activity Readiness Questionnaire, SDS=standard deviation score.

The FTT protocol consists of a 90-second warm-up phase (3.5 km · h^{-1}; 0% incline) followed by the initiation of the test at 3.5 km · h^{-1} and 1% incline for 90 seconds. After this initial period, speed is increased by 0.5 km · h^{-1}, and incline is increased by 2% every 90 seconds. The maximum incline is limited to 15%, but speed is increased with no limitation. The incremental increases in both speed and incline are continued until volitional exhaustion is reached, as described elsewhere.[9] The test is terminated when the participant can no longer keep up with the speed of the treadmill, despite strong verbal encouragement (standardized) (Appendix). At this point, a recovery phase of 90 seconds is initiated at a speed of 2.0 km · h^{-1} on a flat treadmill to ensure normal heart rate recovery.

The 90-second interval of the FTT is based on the interval used in the modified Bruce and Dubowy treadmill protocols. Smaller increments will facilitate better responsiveness in the protocol after an intervention such as an exercise training intervention. The same protocol was used for adolescents and younger children. Participants were instructed not to hold the handrails, except for touching the handrails with 1 or 2 fingers to regain balance during changes in speed and angle of inclination.

The TTE (in minutes; 1 decimal) was determined at peak exercise. The TTE was calculated as the total duration of the test minus the duration of the warm-up phase. The peak heart rate (HRpeak) was defined as the highest value reached during the last 30 seconds before test termination. The test was deemed maximal when HRpeak was greater than 180 beats·min^{-1} and when subjective indicators of maximal effort occurred (eg, sweating, unsteady walking, facial flushing, and clear unwillingness to continue despite strong verbal encouragement).[16]

Before and directly after the exercise test, participants were asked to rate their level of perceived exhaustion on an OMNI scale for perceived exertion (0–10). The scale starts with 0, indicating that the participant is not tired at all, and ends with 10, meaning that the participant is very, very tired. The level of perceived exertion was determined by subtracting the pretest OMNI score from the posttest OMNI score (ie, change in OMNI score).[17]

Table 1.
Participant Characteristics[a]

Characteristic	Boys				Girls				P
	n	$\bar{X}$	SD	Range	n	$\bar{X}$	SD	Range	
Age (y)									
Total	174	13.0	3.7	6.3 to 18.8	182	12.8	3.7	6.1 to 18.9	.700
6–12 y	81	9.6	2.2	6.3 to 12.9	88	9.6	2.2	6.1 to 13.0	.900
13–18 y	93	15.9	1.7	13.1 to 18.8	94	15.8	1.6	13.3 to 18.9	.726
Body mass (kg)									
Total	174	48.5	17.8	18.5 to 92.0	182	46.6	16.3	18.0 to 83.0	.347
6–12 y	81	33.4	9.4	18.5 to 58.5	88	33.8	11.4	18.0 to 66.0	.742
13–18 y	93	61.7	11.8	32.5 to 92.0	94	58.7	9.6	40.0 to 83.0	.042[b]
Body height (m)									
Total	174	1.60	0.21	1.13 to 1.97	182	1.56	0.18	1.17 to 1.86	.016[b]
6–12 y	81	1.42	0.14	1.13 to 1.71	88	1.41	0.14	1.17 to 1.70	.769
13–18 y	93	1.76	0.10	1.44 to 1.97	94	1.69	0.07	1.53 to 1.86	<.001
BMI (kg/m^2)									
Total	174	18.2	2.8	12.6 to 25.8	182	18.5	3.4	10.7 to 28.5	.426
6–12 y	81	16.3	2.1	12.6 to 22.9	88	16.4	2.6	10.7 to 25.7	.995
13–18 y	93	19.8	2.3	15.1 to 25.8	94	20.5	2.7	16.2 to 28.5	.138
BSA (m^2)									
Total	174	1.45	0.36	0.77 to 2.23	182	1.40	0.33	0.76 to 2.06	.218
6–12 y	81	1.13	0.21	0.77 to 1.66	88	1.14	0.25	0.76 to 1.73	.753
13–18 y	93	1.72	0.21	1.13 to 2.23	94	1.65	0.16	1.31 to 2.06	.007[b]
FFM (kg)									
Total	174	40.3	14.3	16.1 to 74.0	180	36.3	11.6	15.1 to 59.5	.011[b]
6–12 y	81	27.9	7.1	16.1 to 46.6	87	26.8	8.0	15.1 to 48.2	.188
13–18 y	93	51.2	9.2	27.7 to 74.0	93	45.2	6.1	32.1 to 59.5	<.001
Body fat (%)									
Total	174	16.4	3.5	7.4 to 27.2	180	20.7	4.0	11.9 to 30.4	<.001
6–12 y	81	15.8	3.7	7.4 to 27.2	87	18.9	3.8	11.9 to 30.4	<.001
13–18 y	93	16.9	3.2	10.8 to 26.1	93	22.4	3.5	15.5 to 30.4	<.001
BMI for age (SDS)[c]									
Total	174	0.0	1.0	−3.2 to 2.3	182	0.0	1.1	−5.1 to 2.5	.936
6–12 y	81	−0.1	1.2	−3.2 to 2.3	88	−0.2	1.2	−5.1 to 2.5	.478
13–18 y	93	0.1	0.9	−2.0 to 2.2	94	0.2	0.9	−1.7 to 2.5	.362
Characteristic	**Total No. of Participants**	**n**	**%**		**Total No. of Participants**	**n**	**%**		
Inactive[d]									
Total	156	0	0		170	2	1		
6–12 y	80	0	0		86	1	1		
13–18 y	76	0	0		84	1	1		
Semi-inactive[d]									
Total	156	5	3		170	12	7		
6–12 y	80	3	4		86	4	5		
13–18 y	76	2	3		84	8	10		

(Continued)

Table 1.
Continued

Characteristic	Boys: Total No. of Participants	Boys: n	Boys: %		Girls: Total No. of Participants	Girls: n	Girls: %		
Semi-active[d]									
Total	156	16	10		170	25	15		
6–12 y	80	7	9		86	14	16		
13–18 y	76	9	12		84	11	13		
Normally active[d]									
Total	156	135	87		170	131	77		
6–12 y	80	70	88		86	67	78		
13–18 y	76	65	86		84	64	76		
Sedentary time of >2 h/d									
Total	166	73	44		177	64	36		
6–12 y	81	31	38		86	27	31		
13–18 y	85	42	49		91	37	41		

[a] BMI=body mass index, BSA=body surface area, FFM=fat-free mass.
[b] Significant at $P<.05$.
[c] Standard deviation score (SDS).
[d] Based on Dutch public health guidelines for recommended levels of physical activity for children and adolescents (5–18 years of age).[15]

Data Analysis

Version 20.0 of IBM SPSS Statistics for Windows (IBM Corp, Armonk, New York) was used for data analysis. The distribution of the variables was assessed with visual inspection (histogram, box plot, and normal quantile-quantile plot) and the Shapiro-Wilk test for normality. Differences between boys and girls in anthropometric variables and exercise variables were examined with Mann-Whitney *U* tests for nonnormally distributed data and the independent sample *t* test for normally distributed data. Determinants of exercise capacity were identified with Spearman correlation coefficients between TTE on the FTT and anthropometric variables. We used the least mean squares method to generate sex- and age-related centile charts (P3, P10, P25, P50, P75, P90, and P97) for TTE (LMS Chartmaker Pro, Medical Research Council, London, United Kingdom). A *P* value of less than .05 was considered statistically significant.

Role of the Funding Source

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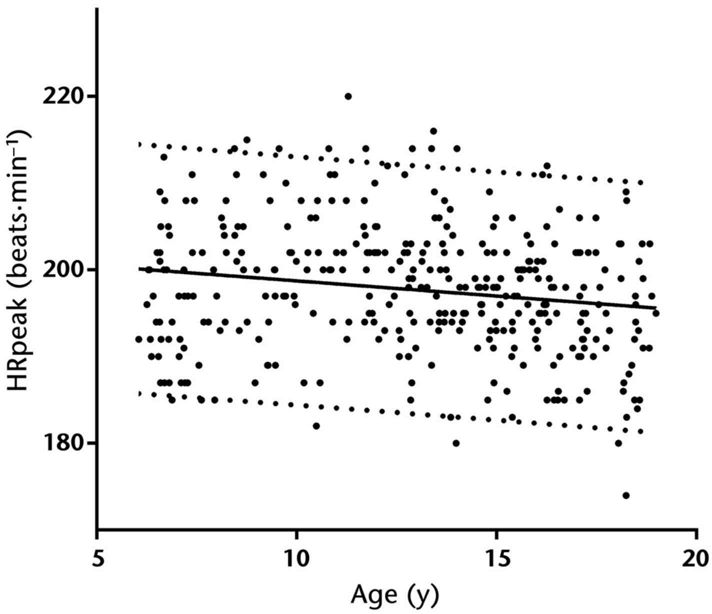

Figure 2.
Age in relation to peak heart rate (HRpeak) reached on the Fitkids Treadmill Test for the total study population.

Results

Participants

Of the 441 children and adolescents who received an information package on the study, 373 children and adolescents (85%) were willing to participate and 361 (82%) were tested. Twelve children (3%) were not tested for the following reasons: 6 had one or more positive answers on the modified Physical Activ-

Table 2.
Fitkids Treadmill Test Results[a]

Parameter	Boys (n=174)			Girls (n=182)			P
	$\bar{X}$	SD	Range	$\bar{X}$	SD	Range	
TTE (min)	13.6	3.1	7.5–24.5	11.6	1.9	7.5–18.3	<.001
HRpeak (beats · min^{-1})	197	7	180–214	198	7	174–220	.011[b]
ΔOMNI	9.2	1.2	3.0–10.0	8.9	1.4	2.0–10.0	.061

[a] TTE=time to exhaustion, HRpeak=peak heart rate, ΔOMNI=change in OMNI score (based on 173 boys).
[b] Significant at $P<.05$.

ity Readiness Questionnaire, one 10-year-old girl fainted during skinfold thickness measurements, and 5 children were excluded because of morbid obesity (BMI SDS >2.5). The remaining 361 children performed the FTT, after which 5 children (1%) were excluded from the analysis for the following reasons: hyperventilation during the FTT (n=1), painful Achilles tendon (n=1), painful leg (n=1), software problems (n=1), and dizziness during the FTT (n=1). Eventually, the data from 356 children and adolescents (81%), 174 boys and 182 girls, with a mean age of 12.9 years (SD=3.7), were used for analysis (convenience sample). A flowchart of the inclusion procedure is shown in Figure 1. Participant characteristics are shown in Table 1.

Test Performance

All participants included in the analysis performed the FTT without any adverse effects, and they all met the subjective criterion of maximal effort. All participants also met the objective criterion of maximal effort during the FTT (HRpeak of >180 beats·min^{-1}), except for one girl, who reached an HRpeak of 174 beats · min^{-1}. However, on the basis of the subjective indicators of maximal effort for this girl, we did include her data in the analysis. Figure 2 shows a scatter plot of the HR_{peak} reached during the FTT in relation to age for the total population.

The FTT results are shown in Table 2. Compared with girls, boys had a prolonged TTE ($P<.001$) and a slightly lower HRpeak ($P=.011$) on the FTT. The main TTEs on the FTT were 13.6 minutes (SD=3.1) for boys and 11.6 minutes (SD=1.9) for girls. The difference in mean HRpeak between boys and girls (197 versus 198 beats · min^{-1}) was not clinically relevant. No statistically significant differences in perceived exhaustion (change in OMNI score) between boys and girls were obtained.

Table 3.
Spearman Correlations Between Time to Exhaustion on the Fitkids Treadmill Test and Anthropometric Variables[a]

Variable	Boys (n=174)		Girls (n=182)	
	r	P	r	P
Age (y)	.779	<.001	.582	<.001
Body mass (kg)	.720	<.001	.515	<.001
Body height (m)	.679	<.001	.433	<.001
BMI	.501	<.001	.325	<.001
BSA	.693	<.001	.446	<.001
FFM (kg)[b]	.720	<.001	.494	<.001
Body fat (%)[b]	−.046	NS	.111	NS
Leg length	.688	<.001	.522	<.001

[a] BMI=body mass index, BSA=body surface area, FFM=fat-free mass, NS=not significant.
[b] FFM and body fat were not determined in 2 girls, so FFM and body fat values were based on 180 girls.

As expected, strong positive correlations were found between TTE on the FTT and age, body mass, body height, body surface area, fat-free mass, and leg length in boys (r values ranging from .679 to .779, with $P<.001$ for all coefficients) (Tab. 3). A moderate positive correlation was found between TTE on the FTT and BMI in boys ($r=.501$, $P<.001$). No correlation was found between TTE on the FTT and body fat in boys. In girls, moderate positive correlations were found between TTE on the FTT and age, body mass, body height, body surface area, fat-free mass, and leg length (r values ranging from .433 to .582, with $P<.001$ for all coefficients). A weak positive correlation was found between TTE on the FTT and BMI in girls ($r=.325$, $P<.001$). In accordance with the results for boys, no correlation was found between TTE on the FTT and body fat in girls.

Figure 3 shows age-related normative centile charts for TTE on the FTT for boys and girls. For practical considerations, we chose to use age instead of body height in the normative centile charts. Age and body height are highly correlated in children and had similar correlations with endurance times in our study population (correlation between age and TTE on the FTT: $r=.649$ [$P<.001$]; correlation between height and TTE on the FTT: $r=.648$ [$P<.001$]). In boys, the normative curves (P50) showed an almost linear increase in TTE with age, from 8.8 minutes at 6 years of age to 16.1 minutes at 18 years of age. In girls, the P50 values for TTE increased from 8.8 minutes at 6 years of age to 12.5 minutes at 18 years of age, with a plateau in TTE starting at approximately 10 years of age.

Discussion

The present study provides sex- and age-related normative values for FTT performance (TTE) in children and adolescents who were healthy, developing typically, and 6 to 18 years old. Because the FTT starts with a flat treadmill, has small incremental steps, and has a lower maximal incline than most established maximal-effort treadmill protocols, it is useful in children and adolescents with limited motor performance or balance

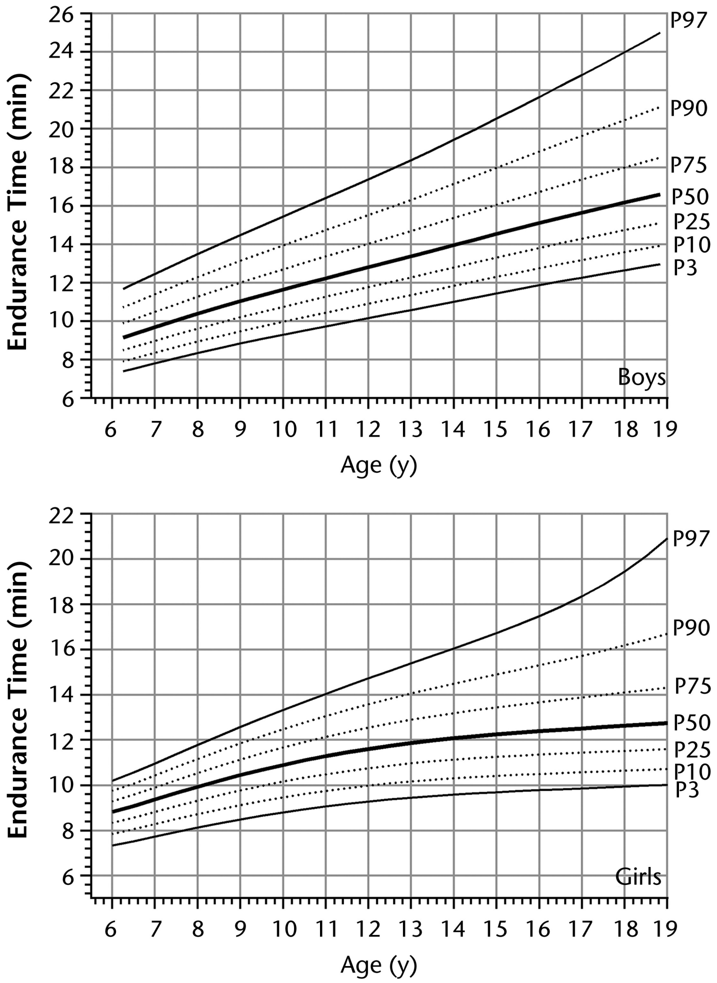

Figure 3.
Age-related centile charts for time to exhaustion (TTE) on the Fitkids Treadmill Test (FTT) for boys and girls separately. The following equations can be used to predict the 50th centile (P50) for TTE on the FTT (minutes) from age (years): for boys—P50 TTE=(0.5870 × age) + 5.688 (R^2=.99); for girls—P50 TTE=(0.8817 × age) + (−0.02359 × age squared) + 4.384 (R^2=.99).

problems or those using an ankle-foot orthosis as well.

Over the past 3 decades, normative values have been reported for standard maximal-effort treadmill exercise protocols, such as the Bruce protocol or the Balke protocol, as well as for several stepwise protocols with increments in speed, incline, or both.[18] Various shortcomings of these studies hinder implementation of the protocols in clinical practice.

Many studies[19–28] assessed outcome measures that require sophisticated respiratory gas-exchange equipment. Other studies[21,23,26,27,29–32] used a treadmill protocol that requires an advanced treadmill with a high slope. Additionally, several studies included limited samples of participants in terms of sample size,[21,24,26] age range,[19,22] environmental conditions (altitude),[28] or ethnic background (nonwhite).[21,25] Some studies assessed outcome measures with individualized treadmill protocols. For instance, in the protocol used by Al-Hazzaa,[25] the speed of the treadmill depended on a child's age and ability to run comfortably on a treadmill. Studies assessing outcome measures with individually tailored treadmill protocols cannot be compared with other studies. A recent extensive overview of existing pediatric norms is available elsewhere.[18]

To our knowledge, no published studies have addressed most of these shortcomings, and no pediatric normative values have been published for exercise parameters that do not require respiratory gas analysis or that use a treadmill protocol that can be applied to a standard treadmill with a maximal incline of 15%. Although Dubowy et al,[29] van der Cammen-van Zijp and colleagues,[30,31] and Binkhorst et al[32] used protocols with a high incline >15%), these studies are of interest for our setting in the Netherlands because they established pediatric normative values for exercise parameters (maximal endurance times) that do not require respiratory gas analysis in a white study population.

Dubowy et al[29] used a stepwise protocol with incremental speed and incline every 90 seconds. They included 1,195 participants who were 3.0 to 75.0 years old.[29] Van der Cammen-van Zijp and colleagues[30,31] and Binkhorst et al[32] used the Bruce protocol. Binkhorst et al[32] included 279 Dutch children who were healthy (6–18 years of age), and van der Cammen-van Zijp et al[30] included 267 Dutch children who were healthy (6–13 years old). In a separate study, van der Cammen-van Zijp et al[31] also described normative values for maximal endurance times in the Bruce treadmill protocol for eighty 4- and 5-year-old children who were healthy. The present study included 356 children who were 6 to 18 years of age. Although Dubowy et al[29] included a large sample, the exact numbers of children and adolescents included were not mentioned. With respect to the studies by van der Cammen-van Zijp and colleagues,[30,31] normative values were established for a slightly broader pediatric age range in the present study (6–18 years in the present study versus 4–13 years in the studies by van der Cammen-van Zijp and colleagues).

In a comparison of the normative curves established for TTE in the present study with those provided by Dubowy et al,[29] similar patterns were obtained. In boys, the normative curve for TTE on the FTT showed an almost linear increase with age. In girls, the increase in TTE on the FTT started to level off at approximately 10 years of age. The endurance time achieved by male participants in the study of Dubowy et al[29] increased until the age of 19 years, whereas in female participants it decreased continuously from puberty. Van der Cammen-van Zijp et al[30] and Binkhorst et al[32] also obtained similar patterns.

Study Limitations

A limitation of the present study is that youth who were not white were underrepresented.

Future Research

Further study of the FTT is warranted and should include investigation of the clinimetric properties and responsiveness in clinical populations, such as children with cardiovascular disease, pulmonary disease, limited motor performance, or balance problems.

In conclusion, the present study provides sex- and age-related normative values for FTT performance in children and adolescents who were healthy, developing typically, and 6 to 18 years of age. In boys, the normative curves showed an almost linear increase in TTE with age. In girls, the values started to level off at approximately 10 years of age.

Ms Kotte, Dr de Groot, Dr Winkler, and Dr Takken provided concept/idea/research design. Ms Kotte, Dr de Groot, Dr Bongers, and Dr Takken provided writing and data analysis. Ms Kotte and Dr Bongers provided data collection and participants. Ms Kotte, Dr Bongers, Dr Winkler, and Dr Takken provided project management. Ms Kotte and Dr Winkler provided fund procurement. Ms Kotte and Dr Takken provided facilities/equipment. Dr Takken provided institutional liaisons and administrative support. Dr de Groot and Dr Winkler provided consultation (including review of manuscript before submission).

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Appendix.
Encouragement

Because the duration of the load phase of the Fitkids Treadmill Test (FTT) differed among the participants, it was difficult to provide standardized encouragement throughout the test for each participant. During the first part of the FTT, encouragements such as "You are doing great, come on" and "Keep on going, great work" were used. When it became clear that a participant was struggling during the test, encouragements such as "OK, keep running; the speed and incline are increasing, and you should try to keep up with the speed of the treadmill" were used. When a participant became exhausted, encouragements such as "Come on, this is the most important part of the test; try to perform one last sprint, give everything you have got" were used.