The Physical Educator Vol. 80 • pp. 137–154 • 2023
https://doi.org/10.18666/TPE-2023-V80-I2-11486

EXERCISE SCIENCE

The Talk Test to Measure Exercise Intensity in Children

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Abstract

The Talk Test (TT) is a measure of exercise intensity that has been used in a variety of populations. This study extends the use of the TT as a method to measure exercise intensity in prepubertal children. Healthy children performed an incremental exercise test and then either an interval-based exercise session on the treadmill or a 30-min free-play activity session in the gymnasium. The subject read a short (~100 word) passage and responded to "can you speak comfortably?" If the subject was able to speak comfortably, it was recorded as the positive (+) stage of the TT. If the individual was able to speak but with some difficulty, it was recorded as the equivocal stage (+/-). If the subject was unable to speak comfortably, it was recorded as the negative (-) stage. Ventilatory threshold (VT) was determined in the laboratory through respiratory gas exchange. During the interval-based activity and free-play session, the TT was used in the prediction of whether the subject was exercising at an intensity below or above their VT. Data analysis was performed with a chi-squared test for determining statistical significance. In both the interval-based exercise session and the free-play activity, the TT was effective at predicting whether the subject was exercising at an intensity below or above their VT. Correct predictions

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were made 73.3% of the time for the interval-based exercise group and 81.6% of the time for the free-play session. The TT appears to be a valid predictor of exercise intensity in prepubertal children participating in interval exercise or free play.

The American College of Sports Medicine (2018) and Centers for Disease Control and Prevention (2019) recommend children and adolescents, 6 to 17 years of age, perform at least 60 min of moderate- to vigorous-intensity physical activity (MVPA) each day. Moderate-intensity exercise is identified as an intensity level below the ventilatory threshold (VT) and vigorous exercise is usually identified as an intensity level above VT (Mezzani et al., 2012). VT, often referred to as anaerobic threshold in older literature, is the point during exercise when ventilation increases disproportionately to oxygen consumption (VO_2) and is a widely accepted marker of sustainable exercise intensity (Poole et al., 2020). In clinical or research settings, the availability of gas exchange equipment allows for objective variables to be recorded and exercise intensity determined. However, outside of these settings, objective measurement of intensity, together with anchoring maximal effort tests (e.g., VO_2 max test), is not widely available. Accordingly, subjective methods to determine and measure exercise intensity are needed.

One method to determine exercise intensity outside the clinical setting is the use of heart rate monitors. Armstrong and Bray (1991) used heart rate monitors to determine children's level of intensity during physical activity. To determine how long children were able to maintain vigorous activity, they recorded heart rate data at 5-, 10-, and 20-min intervals. Of the subjects, 84% sustained vigorous intensity for 5 min at least three times during the week, 18% sustained vigorous intensity for 10-min periods, and about 1.5% sustained vigorous intensity for the entire 20-min period at least three times during the week. Similarly, in preschool-aged children, 85% of the moderate- to vigorous-intensity activity episodes ranged from 5 to 10 min in length (Benham-Deal, 2005). Children's activity patterns are typically not continuous but are stochastic (e.g., stop and go) in nature. Although heart rate monitors can be used outside of a clinical setting to record data and provide immediate feedback to the user, they can be expensive. Further, an anchoring maximal effort exercise test to characterize intensity is necessary. Age-predicted equations (i.e., 220 - age) are of limited value on an individual basis because they can incorrectly estimate individual maximal heart rate (Tanaka et al., 2001) and do not consider other factors such as gender, resting heart rate, and body weight (Whaley et al., 1992).

Another method to determine exercise intensity is the use of the Rating of Perceived Exertion (RPE), which is a subjective measure of exercise intensity widely used in adults (Borg, 1998; Chen et al., 2002; Herman et al., 2006). An RPE of 13 is associated with an intensity of approximately 50% to 70% of VO_2 max and is generally a pleasant and effective intensity for training (Parfitt et al., 2012). RPE scales have been found to be effective in children as young as 9 to 10 years old (Mahon et al., 1997); however, the use of the original RPE scale to measure exercise intensity in children has limitations (Mahon et al., 2003; Utter et al., 2002). It is difficult for children under the age of 11 to use only words and numbers to represent their feelings (Utter et al., 2002). For children to identify how they are feeling while exercising, the Children's OMNI Scale of Perceived Exertion was created and includes pictures and language specific to children, for children to rate their perceived exertion (Robertson et al., 2001). Utter et al. (2002) presented a modified version of the Children's OMNI Scale, called the Children's OMNI Scale of Perceived Exertion for Walking and Running, which includes pictorial representations at different levels of exertion. The scale was used in children between the ages of 6 and 13 years old during graded exercise testing. The results demonstrated that the Children's OMNI Scale of RPE correlated with objective physiological intensity during walking and running (Utter et al., 2002).

A third method to measure exercise intensity outside of the research or clinical setting is the Talk Test (TT; Foster et al., 2018), which is a subjective method in which the researcher asks the question, "Are you able to speak comfortably?" immediately after the subject reads or verbalizes a short (~90 words) passage (Schroeder et al., 2017). A relationship has been shown between ventilatory threshold (VT) and the TT. The physiological mechanism driving the TT is the need to suppress breathing frequency (BF) to allow speech (Brawner et al., 2006; Creemers et al., 2017) at the point breathing frequency would normally increase (Poole et al., 2020), which results in retention of CO_2. While exercising, individuals must decrease their breathing frequency to produce speech. This is especially true at the intensity of the VT, when there is normally a substantial increase in breathing frequency. When an individual is exercising at a level above their VT, the conflict between these needs typically leads to a reduction in the perceived comfort of speaking (Brawner et al., 2006; Creemers et al., 2017).

There are three widely recognized stages of the TT (last positive, equivocal, and negative). When exercising in their last positive stage of the TT, a person is typically exercising at an intensity just below VT. For the moderate- and vigorous-exercise classification (Mezzani et al., 2012), exercising at the last positive stage of the TT is typically indicative of highest range of moderate exertion. When exercising in the equivocal stage of the TT, a person's intensity is very close to their VT, and when exercising at the negative stage of the TT, a person is almost always at an intensity above VT (Dehart-Beverley et al., 2000). At the lowest intensity associated with the negative stage of the Talk Test, a person is often near the second VT (e.g., respiratory compensation threshold), which is the second increase in ventilation that is disproportionate to VO_2 (Foster et al., 2018; Recalde et al., 2002; Rodríguez-Marroyo et al., 2013; & Woltmann et al., 2015). This point is generally considered the transition between the vigorous exercise-intensity domain and the severe exercise-intensity domain (Mezzani et al., 2012).

The TT has been used and found to be a useful way to approximate VT and guide exercise training intensity and in a variety of populations. The TT was used and found to be effective in approximating VT for individuals exercising on both cycle ergometer and treadmill (Persinger et al., 2004). Porcari et al. (2018) utilized percent heart rate reserve (%HRR) and the TT to guide exercise-training intensity in college-aged adults. Despite not needing the anchoring maximal exercise test, which is required in the %HRR method, the TT-based exercise prescription yielded the same results as %HRR relative to improving exercise capacity (Porcari et al., 2018). Thus, the TT can be utilized with healthy adults for prescribing exercise that is within appropriate parameters defined by the American College of Sports Medicine (Dehart-Beverley et al., 2000; Woltmann et al., 2015).

The TT has been used in adults (Dehart-Beverley et al., 2000; Foster et al., 2008) and athletes (Recalde et al., 2002; Rodríguez-

Marroyo et al., 2013; Woltmann et al., 2015) as an effective tool for determining exercise intensity. Foster et al. (2008) found that the TT is an appropriate measure of exercise intensity in adults during stochastic (e.g., interval) exercise. The TT has also been found to be an effective tool to measure exercise intensity in clinically stable cardiac patients (Voelker et al., 2002), in patients with myocardial ischemia (Cannon et al., 2004), with stable coronary artery disease (Brawner et al., 2006), following myocardial revascularization surgery (Zanettini et al., 2012), and for patients in outpatient cardiac rehabilitation programs (Foster et al., 2018; Krawcyk et al., 2017; Lyon et al., 2014).

The TT has been found to be an effective measure of exercise intensity in a variety of adult populations and is a well-accepted subjective measure of exercise intensity (Foster et al., 2018). The first time the TT was utilized in children, results were consistent with the TT response observed in adults during incremental exercise (Sazama et al., 2021). However, it has not been determined if the TT can be utilized to accurately determine exercise intensity during training and/or play in children. The purpose of this study was to determine if the TT can measure exercise intensity in children during interval-based training sessions and free-play sessions.

Method

Subjects

The subjects in this study were children 8 to 12 years of age (N=18). Table 1 shows descriptive characteristics. By parental report, all the children were prepubertal, although formal Tanner Staging was not completed. The University Institutional Review Board (20-BP-126 and 19-CF-445) approved the studies used in this data analysis. All subjects provided written assent, and parents/guardians provided written informed consent. Prior to participation, the children completed the Physical Activity Readiness Questionnaire (PAR-Q) and an Exercise History Questionnaire. This allowed for the identification of contraindications that could disqualify them from participating in the study.

Table 1
Descriptive Characteristics of Children (N = 18)

Variable	Interval-based session (*n* = 10)		Free-play session (*n* = 8)	
	Girls (*n* = 5) *M* ± *SD*	Boys (*n* = 5) *M* ± *SD*	Girls (*n* = 2) *M* ± *SD*	Boys (*n* = 6) *M* ± *SD*
Age (years)	9.6 ± 0.55	10.6 ± 0.89	11 ± 0.0	10.3 ± 1.21
Height (cm)	136.6 ± 4.17	150.6 ± 10.31	147.4 ± 2.69	145.3 ± 8.11
Weight (kg)	32.4 ± 3.92	43.8 ± 8.02	41.8 ± 8.39	45.1 ± 11.89
VO_2max (mL*kg^{-1}*min^{-1})	41.3 ± 7.20	43.5 ± 1.53		
HRmax (b* min^{-1})	192.6 ± 11.93	180.2 ± 8.23	174 ± 8.49	181.7 ± 14.19

Protocol

Protocols included the subjects visiting the laboratory on 3 separate days. The first visit was an orientation and familiarization with the TT and the laboratory environment, which included the motorized treadmill and the gas-exchange equipment. During the first visit, subjects also completed a maximal TT, which was achieved via a modified Balke-type treadmill protocol that is widely used for graded exercise testing. During the first four minutes of the maximal test, the treadmill speed was gradually increased until subjects were walking at a comfortable pace. Following the initial 4 minutes, the grade of the treadmill was increased by 2% every 2 min while the speed remained constant. During the last 30 s of each 2-min stage, the subjects completed the TT by reading the "Pledge of Allegiance" three times (93 words) or a 100-word passage, which was selected as appropriate for their reading level and located on a cue card. After the passage was read, the subjects were asked, "Can you speak comfortably?" Answers that indicated the subject could speak comfortably (with a response of "yes") were recorded as (+). The first point when the subject was uncertain about speaking comfortably ("yes, but") was recorded as (+/-), and the first point when the subject was definitely not able to speak comfortably ("no") was recorded as (-). Heart rate was measured with radio telemetry every 5 s (Polar Vantage XL, Polar USA, Lake Success, New York). The Children's OMNI Scale of Perceived Exertion (Utter et al., 2002) was used in the measurement of RPE. Heart rate and RPE were documented in the last 10 s of each stage.

During the second visit, the subjects completed another maximal exercise test on a motorized treadmill. The maximal exercise test began with the subject completing a 2-min walking warm-up at 1.5 mph. In the first stage of the test, the speed of the treadmill was increased to 3 mph with a 0% grade. During the remainder of the test, speed remained constant while grade increased by 2% every 2 min until the subject indicated they could not continue. During the maximal exercise test, gas exchange was recorded through open-circuit spirometry (Moxus Metabolic Cart System, AEI Technologies, Pittsburgh, Pennsylvania), which was calibrated with a 3.0 L syringe and reference gas concentrations (~16% O_2 and ~5% CO_2 and room air). Gas-exchange data were integrated every 30 s.

The third visit consisted of the subjects completing an interval exercise test on the treadmill or a 30-min free-play session in a gymnasium. For the interval exercise test protocol, subjects began with a 2-min warm-up of walking on the treadmill at 1.5 mph with 0% grade. The TT was performed during the last 30 s of successive 2-min stages. The baseline exercise intensity was performed at a speed and grade that required approximately 30% VT (e.g., very light exercise). This baseline exercise intensity was calculated on the basis of their maximal exercise test. Subsequently, in 2-min stages, the grade was altered to a level predicted to be slightly below, equal to, or above their VT. Speed and grade were then lowered to the level that represented approximately 30% VT. At the end of each 2-min stage, the TT and RPE were performed and responses recorded. If the subject was unable to maintain the exercise protocol for 30 min, the speed and grade were adjusted for the subject to complete the protocol, with the addition of an extra-low intensity stage.

The 30-min free-play session consisted of the subjects engaging in activities of their choice in the university gymnasium. Prior to the free-play session, heart rate monitors (Interactive Health Technologies, LLC, Austin, TX) and wireless microphones were distributed to the subjects to wear. The microphones were clipped to each subject's shirt collar to record their responses to the TT and RPE. Following the free-play experience, the researcher listened to each participant's verbal responses and recorded a positive (+), equivocal (+/-) or negative (-) response for the TT and the number identified for RPE. The HR monitors recorded data every 5 s, and the data were later downloaded onto the IHT Spirit system. Due to COVID-19, ventilatory threshold was not able to be directly measured in the laboratory while the subjects engaged in the free-play session. Accordingly, HR at the last positive stage of the TT and at the first equivocal stage of the TT was recorded and used for analysis.

Activity zones were set up in the gym with basketballs and footballs in Zone 1, soccer balls and volleyballs in Zone 2, and jump ropes and frisbees in Zone 3. The equipment represented what might be available to children on a school playground at recess and provided the subjects choice of activities. Zoning playgrounds has been shown to increase physical activity during recess while allowing children freedom to make choices in which activities they want to participate (Barnas & Ball, 2019). During the last thirty seconds of each 2-min stage, prompted by a whistle, the subjects repeated the "Pledge of Allegiance" three times and responded to "Can you speak comfortably?" with "yes", "yes, but…", or "no". After the TT response, subjects were asked, "How hard do you feel you are working?" so their RPE could be determined. Four RPE posters were placed in the gymnasium and an additional poster was carried around by an investigator during the free-play session. This assisted the children in identifying their RPE.

Statistical Analysis

For both the interval-based data and the free-play data, statistical significance for predicted and observed TT responses was tested with a chi-squared test. A p value of < 0.05 was considered statistically significant.

Results

An analysis was performed on 18 (11 boys, 7 girls) children who performed the TT, a VO_2 max test, and either an interval-based TT or a free-play session TT. Thresholds used in this data analysis were expressed as %VO_2 max at VT on the treadmill and the highest HR the participant achieved during the positive stage of the TT during free play. Predictions were made from the TT. From this, it was determined whether subjects were participating at an intensity above or below their VT. If a subject was working below VT, it was predicted they would be able to speak comfortably during the TT. If a subject was working above VT, it was predicted they would not be able to speak comfortably. Comparisons were made on the basis of predicted and observed TT responses for the interval-based session (Figure 1). Although the negative stage of the TT can be used to identify the respiratory compensation threshold, the focus of this study, on the basis of the moderate- versus vigorous-intensity domains, was limited to the positive and equivocal stages of the TT.

During the treadmill interval sessions, in 73.3% of the cases, the observation matched the prediction, indicating that participants were able to speak comfortably when exercising at an intensity below their VT or that participants were not able to speak comfortably when exercising above their VT. Individuals who were exercising at an intensity above their VT were predicted to not be able to speak

Figure 1
Expected Verus Observed Results of the Talk Test During Interval-Based Exercise

	Not predicted	Predicted
Observed	11	82
Not Observed	28	29
% Correct	73.3%	
% Incorrect	26.7%	

Note. The numbers represent subject responses.

comfortably. Individuals were predicted to speak comfortably when exercising at an intensity below their VT. In 71.8% of the 73.3% cases, participants who were predicted to not speak comfortably were in the negative stage of the TT and those who were predicted to speak comfortably were in the last positive stage of the TT. The chi-squared statistic for the interval-based session was 14.643, which reveals a statistically significant ($p < 0.05$) difference in the expected and observed values for the TT.

During the free-play session, in 81.6% of the cases, the observation matched the prediction, indicating that participants were able to speak comfortably when exercising at an intensity below their VT or that participants were not able to speak comfortably when exercising above their VT. Individuals who were exercising at an intensity above their VT were predicted to not be able to speak comfortably. Individuals were predicted to speak comfortably when exercising at an intensity below their VT (Figure 2). In 78% of the cases, participants were able to speak comfortably at an intensity below their predicted VT. Individuals playing at intensities above their VT were predicted to not speak comfortably. Of these cases, 90.0% were correct. The chi-squared statistic for the free-play session was 45.170, which reveals a statistically significant ($p < 0.05$) difference in the expected and observed values for the TT.

Figure 2
Expected Versus Observed Results of the Talk Test During Free Play

	Not Expected	Expected
Observed	3	71
Not Observed	27	19
% Correct	81.6%	
% Incorrect	18.3%	

Note. The numbers represent subject responses.

Figure 3 shows combined data for the interval and free-play session. Predicted TT responses were correct in 77.0% of the cases. In 76.1% of the cases, individuals were able to speak comfortably when exercising at an intensity below their measured or predicted VT. Individuals playing or exercising at intensities above their measured or predicted VT were predicted to not be able to speak comfortably. In 79.7% of these cases, the prediction was correct and participants were not able to speak comfortably.

Discussion

The purpose of these studies was to determine if the TT can measure exercise intensity in children during interval-based training sessions or free-play sessions. The findings indicate that the TT works as well in children as it does in adults (Foster et al., 2008, 2018) as a predictor of exercise intensity in relation to the VT. In particular, the TT is an effective tool to determine exercise intensity during incremental exercise in healthy adults (Dehart-Beverley et al., 2000), in incremental exercise in children (Sazama et al., 2021), and during stochastic exercise in adults (e.g., interval training; Foster et al., 2008). This data analysis reveals that the TT correctly predicts intensity levels of children during interval exercises 73.3% of the time. This number increases during free play to 81.6%. Another study that

Figure 3
Expected Versus Observed Talk Test Responses Combined for Interval Session and Free Play

	Not Expected	Expected
Observed	14	153
Not Observed	55	48
% Correct	77.0%	
% Incorrect	23.8%	

Note. The numbers represent subject responses.

compares 8- to 12-year-old correct prediction percentages to adult prediction percentages reveals similar results with correct predictions approximately 75% of the time for adult participants (Foster et al., 2008). Thus, the TT is as effective in predicting exercise intensity in children as it is in adults. Identifying the exercise intensities that correspond with VT and just above VT is important to maximize the health benefits gained from MVPA. Predicting VT is an important tool that ensures individuals are working at an appropriate intensity and that can be utilized in various settings. When children are aware of the intensity they should be working at, they can transfer that knowledge to various activity settings (e.g., recess, physical education class, before- and after-school programming) outside of a proctored setting. This is important for children to learn and understand because physically active lifestyles start to develop early in childhood and are then continued through their youth into adulthood (Telama et al., 2014). To date, there has been no valid and reliable tool to prescribe exercise intensity for children during natural exercise patterns or in a free-play setting, yet numerous organizations indicate that children should exercise daily at a moderate to vigorous level of intensity for 60 min or more. The results suggest that the TT may serve this function.

Future research should be conducted in a more natural play setting such as a gymnasium, playground, or park that allows observation of spontaneous stochastic play patterns in children. Further research should be conducted in a physical education class setting. Additional research could expand the age range of the children through observations of adolescents between the ages of 13 and 18. Data from the natural play setting should be compared to data obtained in the laboratory through the use of RPE, HR, and the TT.

Limitations

A special circumstance for this data analysis is that the free-play data does not contain VO_2 data due to the impact of COVID-19. The protocols for this data analysis are different in that the subjects engage in either free play in the gymnasium or interval testing on a treadmill. Additionally, due to the small sample size used in this data analysis, the generalizability of the results is low.

Practical Applications

These results are directly applicable to physical educators. Physical education has the potential to increase MVPA in children (Fairclough & Stratton, 2005; Meyer et al., 2011), but there has not been a child-friendly approach to prescribe exercise at or help children to identify if they are exercising at a moderate to vigorous level. The TT is an accurate and reliable tool to prescribe exercise intensity in children and can be successfully utilized by children to identify their exercise intensity. Results of this study indicate that if children are not able to speak comfortably while engaged in activity, they are working at or near a vigorous level of intensity. If children are still able speak comfortably ("yes"), they are working at a moderate level of intensity. In class, physical educators can ask students to engage in activity at a level at which they can "just barely" talk to a friend and know that they are engaging in a health-enhancing level of activity and working toward reaching their daily goal of 60 min of MVPA. Physical educators can also post the Children's OMNI Scale of Perceived Exertion in their teaching space to help children identify their level of intensity.

Conclusion

The results from this data analysis show that when children are exercising or playing at an intensity below their VT, they are generally able to speak comfortably. This was shown in 76.1% of the cases from this data analysis. When children between the ages of 8 and 12 years old participate in exercise or free play, the TT appears to be a valid measure of exercise intensity, relative to the moderate–vigorous intensity domains. The data indicate that both children and adults can utilize the TT to assess intensity levels accurately. The TT is a useful method to determine exercise intensity because it is low cost, is easy to administer, and does not require a laboratory setting and equipment.

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