Jumping into a Healthier Future: Trampolining for Increasing Physical Activity in Children

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Abstract

Objectives: Physical activity in children and adolescents has positive effects on cardiopulmonary functions in this age-group as well as later in life. As poor cardiopulmonary function is associated with higher mortality and morbidity in later life, increasing physical activity especially in children needs to become a priority. Trampoline jumping is widely appreciated in children, the objective was to investigate its use as a possible training modality.

Methods: 15 healthy children (10 boys and 5 girls) aged 8.8 years undertook an incremental running step test outdoors using a mobile cardiopulmonary exercise testing unit. After a rest period of at least two weeks a trampoline test using the mobile unit was realized by all participants including a 5-minute endurance interval with moderate jumping and two high-intensity intervals with vigorous jumping for 2 minutes, interspersed with 1 minute rests.

Results: During the endurance interval the children achieved B-values slightly higher than VT1 and during the high-intensity interval comparable to VT2 of the running test. They were able to maintain these values for the duration of the respective intervals. The maximum values recorded during the trampoline test were significantly higher than during the incremental running test.

Conclusion: Trampoline jumping is an adequate tool for implementing high-intensity interval training as well as moderate-intensity continuous training in children. As it is a readily available training device and is greatly enjoyed in this age-group this could represent a means for increasing physical activity in children.

What Are The Key Points?

Trampolining is a widely used physical activity in children and adolescents. As the required 60 minutes of physical activity in this age-group have declined dramatically over the last years, motivating children and developing adequate training methods is curucial. High-intensity interval training could provide a more time-efficient approach with a higher fun aspect. We therefore investigated trampolining with respect to its adequacy for HIIT in children using mobile cardiopulmonary exercise testing. This is the first study using cardiopulmonary exercise equipment for evaluating trampolining in children.

Introduction

Cardiorespiratory fitness (CRF) is an objective, reproducible, physiological measure [1] that can be recorded by using maximal graded cardiorespiratory exercise testing and determining peak oxygen uptake () [2].

Evidence of the association between low cardiorespiratory fitness (CRF) and a higher morbidity and mortality from all causes, including cardiovascular disease and cancer has been consistent and strong [3]. An improvement of CRF by 1 ml/kg/min (determined using a maximal bike test) has been shown to reduce the risk for developing overweight or obesity by 10% in 6 years [4]. In addition to that, improving CRF in childhood and adolescence is associated with a healthier cardiovascular profile in later life [5]. Furthermore, a physically active childhood enhances a physically active lifestyle over a life span [6].

As CRF is an objective reproducible physiological measure reflecting the functional influences of physical activity habits, genetics and disease status [7], the aim should be to improve CRF early in life. However, currently CRF of 25.4 million people aged 6 to 19 years from 27 countries has declined by 3.6% per decade from 1985 to 2003 [8]. Even though the WHO recommends that children spend at least 60 minutes per day of moderate-to-vigorous-intensity physical activity [9], most children spend an average of 8 to 9 hours/day in sedentary behavior which in turn tends to increase by 30 minutes per day per year in school-aged children [10]. Consequently, the number of children and adolescents with low CRF gradually increases [11]. It is therefore essential to devise effective exercise modalities fit for the use in very young children to change their general movement pattern towards a higher level of physical activity.

There are two training modalities which have been explored in the literature: Moderate-Intensity Continuous Training (MICT) and High-Intensity Interval Training (HIIT). In HIIT short bursts of high-intensity activity alternate with lower-intensity activity for recovery or rest [12-14]. The intensity for the high-intensive bursts is described as “all-out”, “maximal effort”, “^{3}90% VO_2peak”, “85 – 95% HR max”, or “^{3}100% maximal aerobic speed” [14]. MICT on the other hand consists mainly of aerobic exercise training performed continuously or in intervals [15]. The training modality which shows the most promising effects for improving CRF in children, adolescents and adults is High-Intensity Interval Training (HIIT) [14, 16]. Possible explanations for the success of HIIT compared to MICT are the differing adaptations induced in the mitochondria in the trained muscles and a higher effect on central adaptation such as maximal stroke volume, cardiac output, and blood volume, all being important components of CRF [17-19]. Maybe even more important than its effects, is the smaller time commitment which could increase training adherence [20]. Intermittent exercise also represents children’s spontaneous physical activity [21] and may therefore be better received in this age-group than MICT.

Since HIIT seems to represent an effective approach to achieving improvements in CRF among healthy children and adolescents, we aimed to evaluate a training modality which could be easily accessed by healthy children and already represents an activity widely recognized in that age group: trampolining. A first approach to measuring the intensity of trampoline jumping in children has involved the measuring of accelerometry(ACC)-derived and muscle electromyography(EMG)-based estimates (Gao et al. 2018). However, the two measurements provided different results, with ACC describing trampoline jumping as being of vigorous intensity as a consequence of the body being hurled through space and EMG categorizing it as being of light and moderate intensity as it only involves brief bursts of muscle activity (Gao et al. 2018). Two studies have investigated the physiological demands of trampolining in adults and concluded that trampolining was comparable with respect to to treadmill running at the same intensity [22, 23]. The conclusion of the authors was that even though the cardiopulmonary parameters were significantly higher during trampolining compared to treadmill running, the fact that the trendline associated with each variable was similar, monitoring the intensity of the session based on heart rate during trampolining as is already the custom with running was justified [23].

The question remains, whether trampoline jumping can be categorized as a vigorous or as a moderate intensity physical activity and whether it could be used as a reasonable training modality for HIIT in children.

Material And Methods

The study was approved by the Ethics Committee of the University of Erlangen-Nürnberg, FRG (No. 409_19).

Subjects

Fifteen healthy children aged between seven and ten years of age agreed to participate in this study. Each child as well as their legal guardians gave written informed consent using a consent form approved by the Ethics Committee of the University of Erlangen-Nuremberg, FRG. All participants were Caucasian, non-obese, and healthy and were recruited from local schools.

Body Composition

Height and weight were measured using a stadiometer and electronic scale (Seca 704 S, Hamburg, Germany).

Measurement of

The mobile cardiopulmonary exercise was performed using a mobile testing device (Metamax Ò, Cortex, Leipzig, Germany). A small, low-dead-space respiratory valve (88 ml) with a pediatric mouthpiece and headgear was used. Gas-exchange was measured continuously during each test using a breath-by-breath method and averaged over 15 s intervals. Criteria for completion of a valid peak test included two of the following three criteria: (1) HR ³ 200 beats per minute (bpm), (2) RER ³ 1.0, and (3) volitional fatigue [24]. All children were instructed to abstain from food or carbohydrate rich drinks for the two hours leading up to the test. Ventilatory thresholds VT_1 and VT_2 were determined using the V-slope method proposed by Wasserman et al. [25].

Test protocol

The test was performed outdoors using a step test profile previously described [26]. The children warmed up by running for a few minutes prior to the test for a period of 5 minutes. After a 10 minute rest each child was fitted with a heart rate (HR) monitor (Polar H7 Bluetooth Smart 4.0 Ò heartrate sensor, Kempele, Finnland). The mask was fitted and the backpack containing the mobile exercise equipment (MetaMax 3BÒ, Cortex, Leipzig, Germany) adjusted so it would not move on the child’s torso. The test consisted of 4 steps of 2 minute-lengths. The first increment consisted of walking at a leisurely pace. After 2 minutes the speed increased to an easy jog. Then the speed increased further to running with some effort and lastly to the fastest speed achievable by the child. An experienced researcher and running coach for children performed the whole test alongside each child controlling the speed with a GPS sensor (Garmin Fenix 5SÒ, Garmin, Olathe, USA) in order to slow down the respective child at the beginning of the test and also for motivational purposes toward the end. A GPS sensor integrated in the mobile unit recorded the speed of the child at every moment of the test. Running was performed on a flat and even trail and children were instructed to use sportive footwear and clothing.

Trampoline Testing

A minimum of two weeks later, all children were tested again on the trampoline. They were first fitted with the mobile cardiopulmonary exercise testing device and the heart rate monitor as described above. In order to assess the intensity during leisurely jumping as well as during vigorous exercise, the children were instructed to jump according to the following protocol: The first 5 minutes were spent with easy hopping. The children were instructed to not jump high and to not overexert themselves. After this sort of warm-up phase, followed a rest of 1 minute which the children spent standing in the middle of the trampoline and not moving substantially. After that, 2 minutes of vigorous jumping followed, during which the children were motivated to jump as high as possible, giving them vocal feedback about their maximum heart rate and encouraging them to reach higher heart rates. This vigorous exercise was repeated for a 2 minute interval after another 1 minute rest period spent standing still. All recorded values were then averaged over the timeframe of each phase and the maximum value reached by each child was recorded separately.

Statistical Analysis

Statistical analysis was performed using Microsoft Excel 2000® for data collection and SPSS 12.0® (SPSS Inc., Chicago, IL). All measured values are reported as means and standard deviations. The Kologomorov-Smirnov test was used to check for normal distribution. Homogeneity of variance was investigated using Levine’s F-test. For normally distributed variables, differences between the two test protocols were assessed with paired t-tests, otherwise the Wilcoxon or the Whitney-Mann-U-tests were used. All tests were 2-tailed, a 5% probability level was considered significant (*).

Results

Subjects

We were able to test 15 children outdoors and on the trampoline. Out of the 15 children (mean age 8.8 years, mean weight 27.6 kg, height 133.4 cm, BMI 15.3 kgm^{-2}), 10 were boys (mean age 8.8 years, weight 28.9 kg, height 135.7 cm, BMI 15.5 kgm^{-2}) and 5 were girls (mean age 8.7 years, weight 25 kg, height 128.8 cm, BMI 15 kgm^{-2}). The boys and girls did not differ significantly from each other with respect to age or anthropometric variables. When asked about the subjective effort all children felt tired after having performed the trampoline test but also agreed that they had all enjoyed themselves.

Oxygen Uptake (VO2)

An example of VO2 over the course of the trampoline test is represented in figure 1 along with the VO2-peak value recorded for the outdoor test for this particular child. The oxygen uptake values of all the participants are represented in figure 2 as well as in table 1. The mean achieved during the 5 minutes of easy trampoline jumping was significantly higher than the VO2 at VT1 determined during the outdoor test. During both intervals of vigorous jumping comparable values to VT2, determined during the outdoor test, were achieved. When compared to VO2peak from the outdoor test, the mean values during the first 2 minute interval were significantly lower, but were comparable during the second 2 minute interval. The maximum VO2 determined during the trampoline jumping was significantly higher than determined during the outdoor test.

Heart rate

The heart rate values for the trampoline and the outdoor test are represented in table 1. The mean heart rate during the endurance interval was comparable to the heart rate at VT1 during the incremental step test. The same was true for the heart rate at VT2 and the second high-intensity interval. The mean heart rate during the two minutes of high-intensity was significantly than the peak heart rate during the outdoor test for both intervals. The maximum heart rate achieved during the trampoline test was not significantly higher than the one achieved during the outdoor test.

Oxygen-pulse (O_2-pulse) and Minute Ventilation (VE)

The parameters for O_2-pulse and VE are represented in table 1. The peak O_2-pulse was comparable to the O_2-pulse during both 2 minute high-intensity intervals and significantly higher than during the endurance interval. The maximum O_2-pulse recorded during the trampoline test was significantly higher than during the outdoor test. Mean VE was significantly lower during the two high-intensity intervals than VE, but comparable to the maximum VE value recorded during the outdoor test. The mean VE during the endurance interval was also significantly lower than the peak during the outdoor test.

Discussion

The recommended 60 minutes of moderate-to-vigorous-intensity physical activity [9] is only being met by a minority of children today. Even though it is well known that physical activity can lead to a multitude of benefits and reduction of risk factors [27], most children spend their time with sedentary activities [28]. Cardiorespiratory fitness can be estimated by measuring during an incremental step test [2]. This parameter which is negatively associated with morbidity, and mortality from all causes and especially from cardiovascular disease and cancer [3], can be improved by physical activity [7] and HIIT in particular [14].

Trampoline jumping is a widely used physical activity in children. Therefore trampoline jumping represents an ideal means for promoting physical activity in children. In order to evaluate its intensity during different jumping modalities we investigated slow endurance jumping over a period of five minutes with high-intensity jumping over a period of two minutes.

Eligibility of trampoline jumping for MICT and HIIT

Interestingly during the endurance interval was already higher than at VT1 even though the heart rate was comparable, indicating that the heart rate is not an accurate tool for estimating cardiopulmonary function. The same observation was made for at VT2 which was comparable to both high-intensity intervals but the mean heart rate was significantly lower during the first high-intensity interval and only rose to comparable values during the second high-intensity interval. Slow trampoline jumping could therefore be an adequate tool for moderate-intensity continuous training in children as it can be performed close to at VT1. However, the children stated that they were bored during the slow jumping and felt no tiredness afterwards. The vigorous jumping was much more enjoyable according to their accounts and was performed with -values at VT2, thus representing high-intensity interval training.

As the mean achieved during the second high-intensity interval was not significantly lower than from the incremental step test, and the maximum recorded during the trampoline test was significantly higher, the children were not only able to achieve peak oxygen uptake or even more during vigorous trampoline jumping but were also able to sustain this high intensity for a duration of two minutes as can be seen in the exemplary data represented in figure 1. These findings suggest that a true can be achieved during trampoline jumping by kids.

Two previous studies have investigated the cardiopulmonary effects of trampolining [22, 23]. The maximum recorded during vigorous jumping was around 40 ml kg^{-1} min^{-1} in healthy, adult males [23, 22] , which is significantly lower than the maximum recorded in our study (55.6 ml kg^{-1} min^{-1}). Children tend to achieve higher -values than adults during cardiopulmonary exercise tests [29], which can explain this discrepancy. Also in these previous studies, -values during vigorous trampolining did not differ significantly from vigorous running on the treadmill [22, 23], whereas the children in our study achieved significantly higher values during jumping than running. A possible explanation for this difference could be the higher fun factor of the trampoline in a young age-group. The children were maybe more willing to fully exhaust themselves on the trampoline than while running outdoors. Comparable test protocols are needed to evaluate this finding further.

Cardiac and pulmonary contribution during trampoline jumping

The cardiac output, indirectly measured through the O_2-pulse, was comparable during both high-intensity intervals and at during the outdoor test. Interestingly, the minute ventilation was significantly lower during both high-intensity intervals than at during the outdoor test, but the maximum value during trampoline jumping and incremental step test was comparable. This indicates that peak O_2-pulse was reached by the children during the trampoline test, they were able to maintain this high cardiac output for the full duration of the high-intensity interval. On the other hand peak   reached during trampoline jumping and outdoor running was comparable, but could not be maintained over a timeframe of two minutes either as a consequence of rising too slowly or of being too difficult to keep up.

This study has several limitations. First of all the number of participants is small and more significant differences might have become apparent with a higher number of children. There was no evaluation of the power realized during the trampoline jumping as the determination of metabolic equivalents for trampoline jumping is not established yet.

Conclusion

As the test subjects in this study were able to achieve -values at VT2 which they were then able to maintain for a duration of 2 minutes twice with only one minute rest in between, trampoline jumping could be a very effective way to achieve HIIT in young children. The children all stated that the vigorous jumping had be tremendous fun and much more enjoyable than the slow endurance jumping. As it is a readily available training device for most families (either at home or in a near-by facility) it could be used for promoting physical activity in children through High-intensity interval training interventions.

Declarations

Funding: No funding was received

Conflicts of interest/Competing interests there were no conflicts of interest or competing interests

Availability of data and material: can be made available upon reasonable request

Code availability: Not applicable

Authors' contributions

Author's name	*Conception and design of the study*	*Data acquisition,*	*Data analysis and interpretation*	*Drafting of Manuscript*	*Critical Revision of Manuscript*	*Accountability for all aspects of work, ensuring integrity and accuracy*
IS	√	√	√	√	√	√
BE	√	√	√	√	√	√
KR	√	√	√		√	√
AW	√	√	√		√	√
SD	√				√	√
VS	√	√			√	√

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Ethics approval: the study was approved by the Ethical Board of the University of Erlangen-Nürnberg, No. 409_19

Consent to participate: Each child as well as their legal guardians gave written informed consent using a consent form approved by the Ethics Committee of the University of Erlangen-Nuremberg, FRG.

Consent for publication: Consent to publication was given by all authors

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Table

Table 1: Mean values measured during the incremental running outdoor test compared to the mean values measured for the endurance and high-intensity intervals as well as the maximum values during the trampoline jumping test

		Running test			Trampoline test		
	Peak	**VT1**	**VT2**	**Endurance**	**1st interval**	**2nd interval**	**Maximum**
VO2 (mL kg^{-1} min^{-1})	50.4 (4)	24.6 (7.3)	46.2 (5.4)	30.4 (4.1)	47.1 (5.6)	48.3 (6.9)	55.6 (6.7)
O_2-pulse (mL)	7.4 (1.9)			6.2 (1.1)	7.4 (1.6)	7.5 (1.8)	8.2 (2)
Heart rate (min^{-1})	191.7 (8.3)	130.4 (12.6)	183 (10.3)	133.6 (10.8)	173.8 (10.2)	183 (10.3)	189.6 (8.3)
VE (L min^{-1})	53.9 (11.2)			24.3 (3)	45.6 (9.3)	47 (11)	52.9 (12)

Figures

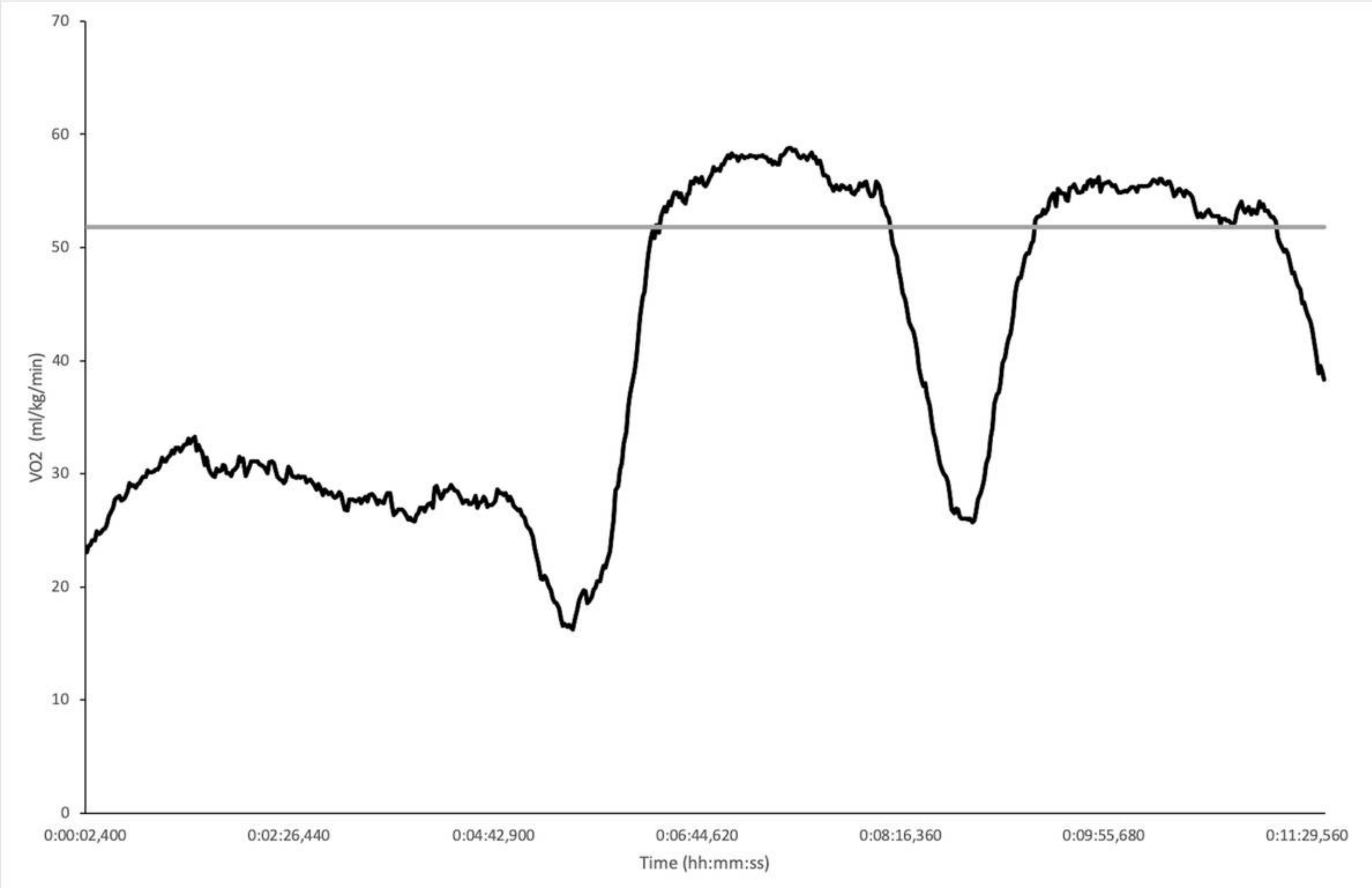

Figure 1

An example of V̇ O_2 over the course of the trampoline test along with the V̇ O_2-peak value recorded for the outdoor test for this particular child

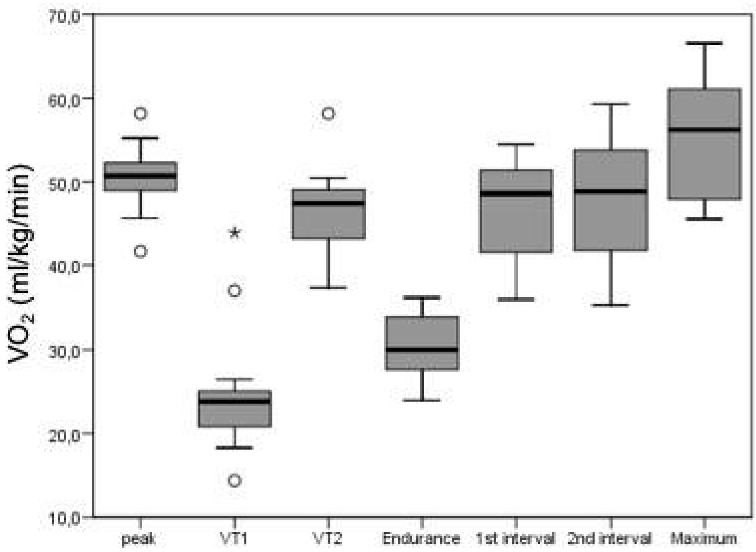

Figure 2

Mean values of the oxygen uptake of all the participants