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**Title:** Heart rate responses during the modified six-minute walk test among Special Olympics athletes

**Year:** 2021

**Version:** Published version



**Please cite the original version:**

Stuart-Hill, L., Ryan, P., St. John, L., Rintala, P., & Temple, V. (2021). Heart rate responses during the modified six-minute walk test among Special Olympics athletes. Turkish Journal of Sports Medicine, 56(2), 56-60. https://doi.org/10.47447/tjsm.0493

Spor Hekimliği Dergisi
*Turkish Journal of Sports Medicine*
*Turk J Sports Med.* 2020 Dec 21; doi: 10.47447/tjsm.0493

**Research Article / Araştırma Makalesi**

# Heart rate responses during the modified six-minute walk test among Special Olympics athletes

# *Özel Olimpiyatlar sporcularında modifiye altı dakikalık yürüme testi sırasında elde edilen kalp atım hızı yanıtları*

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**ABSTRACT**

**Objective:** The construct validity of the modified six-minute walk test (m6MWT) was examined by addressing the following questions: 1) do participants attain a steady state plateau in heart rate (HR) within the range of 110-150 beats per minute? 2) at what percentage of their predicted HR maximum were participants during each minute of the test?

**Material and Methods:** Participants were 36 (male=56%) Special Olympics athletes aged 34.4 years (SD = 12.7). Following familiarization, participants completed the m6MWT while wearing a Polar Team 2 heart rate monitor.

**Results:** By the end of the first minute, average heart rate was 120bpm, and a factorial repeated measures ANOVA revealed that steady state was achieved by minute three.

**Conclusion:** The construct validity of the m6MWT was supported as two assumptions were met: that steady state HR was achieved and the work load was intense enough that steady state HR fell within the range of 110-150bpm.

**Keywords:** *Physical fitness testing, adaptive sports, cardiorespiratory fitness, validation study, instrumentation*

**ÖZ**

**Amaç:** Modifiye altı dakikalık yürüme testinin (m6MWT) yapısal geçerliliği, aşağıdaki sorulara yanıt aranarak incelenmiştir: 1) Katılımcıların kalp atım hızı (KAH) dakikada 110-150 atım aralığında kararlı duruma ulaşır mı? 2) Katılımcılar testin her bir dakikasında hangi oranda tahmini maksimum kalp atış hızına ulaşır?

**Gereç ve Yöntem:** Çalışmaya yaş ortalaması 34.4 olan (SS = 12.7) 36 (erkek =% 56) Özel Olimpiyatlar sporcusu katılmıştır. Alıştırmanın ardından, katılımcılar Polar Team 2 kalp atım hızı monitörü ile m6MWT'yi tamamlamıştır.

**Bulgular:** İlk dakikanın sonunda, ortalama kalp hızı 120 atım / dakika olarak bulunmuştur ve kararlı duruma faktöriyel tekrarlı ölçümler ANOVA testi ile üçüncü dakikada ulaşıldığı görülmüştür.

**Sonuç:** İki varsayımın da karşılanmış olması, m6MWT'nin yapısal geçerliliğini desteklemiştir; kalp atım hızında kararlı duruma erişilmiş, iş yükü kararlı duruma 110-150 atım/dakika aralığında ulaşılan yoğunlukta bulunmuştur.

**Anahtar Sözcükler:** *Fiziksel uygunluk testi, adaptif spor, kardiyorespiratuar uygunluk, doğrulama çalışması, enstrümantasyon*

## INTRODUCTION

The American College of Sports Medicine (1) describes cardiovascular fitness as the ability of the body to take in, transport and use oxygen while exercising. Cardiovascular fitness has a strong inverse relationship with cardiovascular disease and all-cause mortality (2-4) and a direct relationship with aerobic athletic performance (5). Among individuals with intellectual disability, a condition “characterized by significant limitations both in intellectual functioning (reasoning, learning, problem solving) and in adaptive behavior, which covers a range of everyday social and practical skills” (6), cardiorespiratory fitness is predictive of mobility and daily functioning among older adults (7) and levels of body fat among adolescents (8).

Cardiovascular fitness is an objective parameter that can be assessed by exercise tests. The purpose of these tests is to determine the peak volume of oxygen ($VO_2$peak) that can be consumed during exercise as the higher the $VO_2$peak value, the greater the cardiovascular fitness and associated

**Received / Geliş:** 15.09.2020 · **Accepted / Kabul:** 27.10.2020 · **Published / Yayın Tarihi:** 21.12.2020

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**Cite this article as:** Stuart-Hill L, Ryan P, St. John L, Rintala P, Temple V. Heart rate responses during the modified six-minute walk test among Special Olympics athletes. *Turk J Sports Med.* 2020 Dec 21; http://dx.doi.org/10.47447/tjsm.0493

health benefits (1). Direct measurement of $VO_2$peak in a laboratory using respired gas analysis is considered to be the criterion measure to assess and classify aerobic fitness and to form the basis for aerobic fitness exercise prescription (1). However, direct measurement is not always practical or possible to do as it requires costly equipment, considerable amounts of time, highly trained personnel, and a motivated participant capable of maximal exertion.

Alternatively, submaximal exercise tests can be used to predict $VO_2$peak. Test protocols using a wide variety of exercise modes have been developed, however, a walking test; particularly for some populations such as the elderly or those with an intellectual disability may be preferred as walking is a natural and habitual physical activity (9, 10). For these predictive, submaximal tests to be considered valid measures of aerobic fitness they must demonstrate concurrent validity. Concurrent validation is a type of criterion-related evidence that is used when a test (such as a $VO_2$ peak test) is to be substituted by a simpler or easier test (such as a submaximal, predictive test).

The six-minute walk test (6MWT, 11) is a single-stage submaximal predictive test that uses one submaximal HR and one workload that has shown concurrent validity in adults with intellectual disabilities (16). The test involves walking as quickly as possible on a flat, hard surface, for a period of six minutes. Standard phrases of encouragement are provided at the end of each minute and there is no warm-up. Compared with previously validated sub-maximal cardiovascular fitness tests for individuals with intellectual disability such as the 1-mile (1.6 km) (12) and the 1.5-mile (2.4 km) (13) tests, the 6MWT is shorter in duration and requires less space to conduct the test (e.g., a corridor compared to a track or gymnasium).

Among adults with intellectual disability, task understanding and motivation (14, 15) and consistency of effort (16) can affect fitness test results. Therefore, Nasuti, Stuart-Hill, and Temple (17) incorporated several accommodations to enhance comprehension, motivation, and maximal effort without changing the performance requirements of the test. Consistent with previously reported fitness testing protocols for adults with intellectual disability (e.g. 18, 19), a pacer was provided and participants were familiarized with the protocol, equipment, environment, and staff. The pacer walked 1 - 3m ahead of the participant; and standardized phrases of encouragement were provided every 15-s. This version of the test, referred to as the modified six-minute walk test (m6MWT), has excellent feasibility and test-retest reliability and substantial relationships with peak oxygen uptake ($VO_2$peak) among adults with intellectual disabilities (17, 20). The strong test-retest reliability and feasibility of the m6MWT when a pacer is used has also been demonstrated among adolescents with intellectual disabilities (21) and those with severe intellectual and sensory disabilities (22).

What has not been determined however, is if the m6MWT meets the two assumptions required for the efficacy of a submaximal test as outlined by Heyward (23). The validity of submaximal predictive tests are based on two other assumptions besides concurrent validity; 1) that a steady-state heart rate is achieved and is consistent for each exercise work rate, and 2) that a linear relationship exists between $VO_2$ and heart rate (HR) within the range of 110-150 beats per minutes (23). Steady-state HR is usually achieved in 3-4 minutes at a constant, submaximal work rate (23). Submaximal tests can be performed using a single workload or multi-workloads at increasing intensities. Mahar and colleagues (24) have shown that the accuracy of a single-stage and multi-stage model for predicting $VO_2$max is similar. That is, that a steady-state heart rate is achieved and is consistent for each exercise work rate, and that this steady state heart rate (HR) is within the range of 110-150 beats per minutes where there is a linear and predictive relationship with $VO_2$.

The purpose of this study was to contribute to the construct validity evidence of the m6MWT as a submaximal test of cardiorespiratory fitness by describing the HR response profile of adults with intellectual disabilities during the walk test. Construct validation refers to process of establishing that the construct is consistent with the theories of which the construct is a part and can involve multiple sources of evidence (25). This study focused on whether the m6-MWT produced heart rate responses consistent with theoretically expected responses for a submaximal fitness test (23). The following specific research questions were addressed: 1) did the participants attain a steady state plateau in HR within the range of 110-150 bpm? 2) at what intensity were participants perfoming the test each minute as a percentage of their predicted HRmax? Evidence of these two assumptions being met by the m6MWT will provide cross-validation of it's power as an indicator of aerobic fitness in adults with intellectual disability, including those with Down syndrome.

## MATERIAL and METHODS

### Participants

A convenience sample of participants was recruited from Special Olympics British Columbia (SOBC) locals on Vancouver Island and lower mainland. Participants were eligible to participate if they were between 18 and 70 years of age and were participating in the Special Olympics BC Functional Testing. The functional testing is optional for all SOBC athletes and is designed to measure aspects of fitness and function to help coaches guide athlete training (26). In total, 36 athletes (16 female, 20 male) completed the modified Six-Minute Walk Test (m6MWT; 17), including five participants with Down syndrome (4 female, 1 male). Descriptive statistics for age, body mass index (BMI), and predicted maximum heart rate are shown in Table 1. Approval for this study was granted by the Human Research Ethics Board of the University of Victoria BC, Canada, and by SOBC, ethics protocol number 13-518, 23 January 2014. Written informed consent was obtained from each athlete or participant's legal guardian. When consent was obtained from a guardian, the athlete provided assent.

### Measures

**The modified six-minute walk test (m6MWT):** The m6MWT (17) was used to measure cardiorespiratory fitness. Nasuti et al. demonstrated that the m6MWT has adequate concurrent validity ($R^2$ = 0.67) with the The Graded Maximal Treadmill Test (13) and strong test-retest reliability (ICC = 0.98) among adults with intellectual disability. The test involved walking as quickly as possible for six minutes on an indoor flat, hard surface, along a straight 30 metre path, and around a cone at each end of the path. A pacer walked 1 - 3 metres ahead of the participant and the pacer provided standard phrases of encouragement e.g. "your doing well" every 15-seconds. At the end of each minute the pacer indicated how many minutes to go. The path was marked at 2-metre intervals with floor tape, and at the completion of the test, the research assistant timing and recording laps placed a piece of floor tape at the heel of the last step taken by the participant so that total distance walked in metres could be counted.

**Heart rate measurement:** During the m6MWT HR was monitored using Polar Team 2 heart rate monitors (Polar Electro, Lachine, QC). The Polar heart rate monitors were attached to the chest using an elastic chest strap. The electrodes on the strap detected HR and the data were stored on a monitor that clipped onto the front of the strap to be later downloaded onto a laptop into Polar Team 2 software. Once downloaded, the data were analyzed by looking at the HR response as beats per minute.

**BMI and demographic information:** Demographic information was obtained from each athlete's current SOBC Athlete Medical Form and height and weight were measured on the same day as part of the SOBC Functional testing (26). Consistent with SOBC's Functioning testing, "extra" clothing e.g. jackets and hats were removed and shoes were off when height and weight were measured.

### Procedures

Athletes who chose to participate in SOBC's Functional testing were invited to participate in this descriptive study. Interested athletes, or their legal guardians, then completed an informed consent document with the assistance of a research assistant. These research assistants had completed three training sessions prior to data collection. This training included how to: administer the informed consent/assent, administer and familiarize participants with the m6MWT, how to correctly and respectfully fit a heart rate monitor belt, and strategies to keep athletes focused and engaged.

Athletes were fitted with a Polar Team 2 heart rate monitor via a belt around their chest and a watch on their wrist. Athletes were familiarized with the m6MWT by observing a research assistant complete two laps of the course and then completed two laps themselves with a pacer. After a brief rest, each athlete completed the m6MWT with a pacer providing encouragement and another research assistant keeping time and recording laps completed. During the m6MWT, HR data were collected continuously. At the end of six-minutes the athlete rested until their HR returned to pre-exercise levels, the heart rate monitor was then removed, and the athlete was provided with a juice box.

**Data treatment and analysis:** Data were uploaded into Polar Team 2 software. The mean HR was computed for the six-minutes and for each minute of the test. These means were then compared to the athlete's predicted maximal HR computed using the following equations: for athletes without Down syndrome 220 - age in years, and for athletes with Down syndrome, 210 - 0.56 (age) - 15.5 (27).

Descriptive statistics were computed for age, distance walked, BMI, predicted maximal HR, and resting HR. For each minute of the test, mean (SD) absolute HR and percent of predicted maximal HR (HRmax) were computed. To examine change in absolute and percent of predicted HRmax during the m6MWT, two factorial repeated measures analyses of variance (ANOVA) were computed with time as the independent variable and sex as a between-subjects factor. Data for both repeated measures ANOVA were examined for violations of sphericity (i.e. $p < .05$ on Mauchley's test) which checks "that the variances of the differences between data taken from the same participant ... are equal" (28).

## RESULTS

Table 1 shows the average distance walked by participants during the m6MWT and the predicted HRmax. A factorial repeated measures ANOVA was used to examine the effect of time (per minute of the m6MWT) on absolute HR (see Table 2) with sex as a factor. Mauchly's test indicated that the assumption of sphericity had been violated for the main effect of time on absolute HR, $x^2(20) = 251.5$, $p < .001$. Therefore degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity. There was a significant main effect of time on absolute HR, $F(1.84, 63.67) = 129.70$, $p < .001$. Contrasts revealed that resting HR was significantly lower than heart rates during each minute of the test and that the average HR during minute one was significantly lower than in subsequent minutes. Average HR during minute 1-2 was also significantly lower than during minutes 4-5 and 5-6. There were no significant changes in absolute HR between minutes 3 and 6. The factorial repeated measures ANOVA revealed there was no significant interaction between sex and absolute HR, $F(1.84, 63.67) = 60.48$, $p = .847$.

**Table 1.** Descriptive statistics of athlete characteristics

| | Male ($n$ = 20) | | | Female ($n$ = 16) | | |
|---|---|---|---|---|---|---|
| **Variables (units)** | Mean | SD | Range | Mean | SD | Range |
| **Age (years)** | 35.1 | 11.8 | 21-69 | 34.4 | 12.7 | 18-57 |
| **BMI (kg/m²)** | 26.1 | 5.8 | 11-40 | 28.8 | 8.5 | 11-39 |
| **Predicted Max HR (bpm)*** | 183.5 | 12.2 | 151-199 | 179.9 | 16.5 | 150-202 |
| **Distance walked (metres)** | 594.4 | 87.4 | 441-802 | 553.1 | 97.1 | 332-682 |

*Note.* Max HR calculated using 220 – age, except adults with Down syndrome where the following formula was applied 210 – 0.56 (age) – 15.5 (12), BMI (kg/m²), Body Mass Index (kilogram/meters squared), Max HR (bpm), Maximum Heart Rate (beats per minute).

**Table 2.** Mean absolute heart rate values before and during each minute of the modified 6-minute walk test

| | Heart rate in beats per minute (min) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Rest | | 0-1 min | | 1-2 min | | 2-3 min | | 3-4 min | | 4-5 min | | 5-6 min | |
| | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* |
| **All** | 77.7 | 13.2 | 120.2 | 21.7 | 130.3 | 20.6 | 133.2 | 21.3 | 134.3 | 20.5 | 135.9 | 20.4 | 138.2 | 21.1 |
| **Male** | 76.9 | 12.9 | 119.3 | 20.3 | 127.8 | 17.6 | 131.6 | 19.2 | 133.3 | 18.7 | 135.4 | 19.2 | 136.8 | 18.3 |
| **Female** | 78.8 | 14.0 | 121.3 | 24.0 | 133.4 | 24.1 | 135.1 | 24.1 | 135.6 | 23.1 | 136.6 | 22.5 | 139.9 | 24.6 |

A second factorial repeated measures ANOVA was used to examine the effect of time (across the m6MWT) on percent predicted HRmax (see Table 3) with sex as a factor. Mauchly's test indicated that the assumption of sphericity had been violated for the main effect of time on absolute heart rate, $x^2(14) = 135.0$, $p < .001$. Therefore degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity. There was a significant main effect of time on percent predicted HRmax, $F(2.12, 72.23) = 32.01$, $p < .001$. Contrasts revealed that percent predicted HRmax during minute 0 -1 was significantly lower than during each subsequent minute of the test and that the percent predicted HRmax during minute 1-2 was significantly lower than during minutes 4-5 and 5-6. There were no other significant differences across time in the proportion of time in each predicted HRmax category. The factorial repeated measures ANOVA revealed there was no significant interaction between sex and percent predicted HRmax, $F(2.12, 72.23) = 0.42$, $p = .672$.

**Table 3.** Mean percent of predicted heart rate maximum during each minute of the modified 6-minute walk test

| | *Percentage of predicted heart rate maximum* | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Minutes 0-1 | | Minutes 1-2 | | Minutes 2-3 | | Minutes 3-4 | | Minutes 4-5 | | Minutes 5-6 | |
| | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* |
| **All** | 66.0 | 10.2 | 71.6 | 9.8 | 73.2 | 10.2 | 73.91 | 9.9 | 74.7 | 9.7 | 75.9 | 9.9 |
| **Male** | 65.0 | 9.8 | 69.7 | 8.2 | 71.7 | 9.0 | 72.6 | 8.6 | 73.7 | 8.4 | 74.5 | 7.9 |
| **Female** | 67.2 | 10.9 | 74.1 | 11.3 | 75.1 | 11.5 | 75.4 | 11.5 | 76.0 | 11.2 | 77.7 | 11.9 |

## DISCUSSION

The concurrent validity and reliability of the m6MWT as a predictive test of peak oxygen uptake and cardiovascular fitness in adults with intellectual disabilities has been previously established (17). This research added construct validity for the m6MWT as the data confirmed the assumptions required for the efficacy of a submaximal predictive test. These two assumptions are; 1) that a steady state HR is achieved and is consistent for each exercise work rate, and 2) that the work load is intense enough that steady state HR falls within the range of 110-150 beats per minute as there is a linear relationship between HR and $VO_2$ within this range (Heyward, 2010).

After the first minute of the m6MWT, average HR was 120 beats per minute. By minute 3, average HR was 134 beats per minute and showed no significant increase for the remainder of the test. Thus, steady state HR was achieved during the test for the last four minutes of the test even though self-paced tests can be vulnerable to changes in speed and effort by the participant. The intensity of work chosen by participants also resulted in the steady state HR meeting the criteria of assumption 2, that HR fell within the range where there is a known linear relationship between HR and $VO_2$. There was no sex effect indicating that both male and female participants were able to meet the steady state and the exercise intensity criteria.

The goal of a predictive cardiovascular fitness test is to produce a sufficient level of exercise stress without causing undue or unsafe physiological or biomechanical strain. Inappropriate test selection may also lead to either understressing or overstressing the individual and can lead to invalid conclusions because of ceiling or floor effects (29). Tests such as the m6MWT have been developed to meet the needs of people with various functional limitations and disabilities. Walking for a given duration of time corresponds to functional activites used in daily activities and by allowing the individual to walk at a pace comfortable for them mitigates the risk of overexertion (29). ACSM guidelines recommend that untrained individuals exercise at 70-75% of heart rate maximum to avoid excessive exercise stress and as fitness improves the intensity can be increased to 80-85% of maximum heart rate. During the m6MWT, HR reached 72% of predicted HRmax by minute two and showed no significant change through to the end of the test. There was no effect of sex on these results, indicating that both male and female participants maintained a walking pace that met ACSM suggested guidelines (1) for exercise intensity. A limitation of this study is that all participants were Special Olympics athletes participating local and regional sporting events, practices, and training. Therefore it is reasonable to assume they represent an active segment of this population who are used to exercising. Further research is needed to examine whether these finding hold for individuals with an intellectual disability who are not Special Olympics athletes.

## CONCLUSION

The construct validity of the m6MWT for use with individuals with an intellectual disability was supported as steady state heart rate was achieved and the work load was intense enough that steady state heart rate fell within the range of 110-150bpm.

***Conflict of Interest / Çıkar Çatışması***

The authors declared no conflicts of interest with respect to authorship and/or publication of the article.

***Financial Disclosure / Finansal Destek***

The authors received no financial support for the research and/or publication of this article.

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