Original Article

Can Singing Evoke a Significant Cardiovascular Response on a Six-Minute Treadmill Walk Test?: A Crossover Study

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ABSTRACT

Objectives: This study compared the effects of the Six-minute Treadmill Walk Test (6MTWT) and Six-Minute Treadmill Sing Walk Test (6MTSWT) on cardiovascular parameters.

Study design: Crossover study.

Setting: Undergraduates of Obafemi Awolowo University, Ile-Ife, Nigeria.

Subjects: Thirty-five healthy individuals.

Methods: The participants performed both the 6MTWT and the 6MTSWT in random order with a 10-minute rest interval between. The 6MTSWT was the same as the 6MTWT with the exception that the participants were required while walking to sing along to a popular local song rendered at 80 beats per minute through a headset and synchronized to the treadmill speed. Pre-and-post-walk systolic blood pressure (SBP), diastolic blood pressure (DBP), pulse rate (PR), rate of perceived exertion (RPE), and rate pressure product (RPP) were recorded.

Results: Each test resulted in a significant difference in SBP, RPP, and RPE ($p < 0.05$). There were also significant differences between the groups in mean change of PR with 6MTWT and 6MTSWT (2.37±3.90 vs. 0.54±3.24; t= 2.133; $p = 0.037$, respectively) and RPP (776.80±602.24 vs. 483.86±399.28; t = 2.398; $p = 0.019$, respectively).

Conclusions: Slow-tempo singing decreases PR and RPP significantly during 6MTWT among healthy young individuals.

Keywords: six-minute treadmill walk test, cardiovascular parameters, singing, walk tests

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Introduction

The American Thoracic Society (ATS) guidelines[1] stipulate the standard length of the hallway in a six-minute Walk Test (6MWT) to be 30 meters long, and the standard width to be 3 meters. However, finding the required space may be problematical in some centers. Preliminary data have shown that the six-minute treadmill walk test (6MTWT) protocol is a feasible and reliable alternative for predicting maximal oxygen consumption and assessing heart rate in apparently healthy adults.[2] It has also been reported that 6MTWT is a cost-effective measure for determining parameters of an exercise prescription, especially exercise intensity in a clinical environment.[3]

Although undertaking 6MTWT can resolve problems of limited space, consumes less time, and allow constant monitoring during the exercise,[4] few studies have utilized a treadmill instead of a corridor walk for 6MWT.[5,6] More importantly, data on the effect of singing during a 6MTWT is limited, although there is evidence of the effects of singing on cardiovascular parameters.[7-9] Specifically, some researchers have reported varying effects of different kinds of music on some cardiovascular parameters, including blood pressure and pulse rate.[10,11] Additionally, singing has been associated with a 10% reduction in the rate of perceived exertion during the exercise of a low-to-moderate intensity.[7,12-14]

Singing has been widely used to accompany athletic activity as a way to enhance the psychological state, establish an effective mindset, sustain motivation, resist mental and emotional fatigue, as well as to facilitate physical and athletic performance.[12,15,16] However, the effects of singing seem to have been less explored among patient populations undertaking the 6MTWT even though cardiorespiratory dysfunctions are among the main indications for them to undergo the test. It is possible that the cardiovascular parameters of patients who undergo 6MTWT can be positively improved if singing is incorporated into the procedure. Moreover, due to its peculiar characteristics, singing is increasingly employed in the rehabilitation of patients with medical, physical, and psychosocial problems.[16]

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To our knowledge, no studies have been conducted to ascertain if singing can enhance cardiovascular parameters during 6MTT. This study aimed to compare the effects of 6MTWT and the six-minute treadmill sing walk test (6MTSWT) on cardiovascular parameters in apparently healthy individuals.

Methods

Participants

After obtaining ethical approval for the study, male and female undergraduates of Obafemi Awolowo University, Ile-Ife, Nigeria, were recruited purposively after obtaining their written consent. Inclusion criteria included: (1) undergraduates age between 18 and 28 years, (2) stable blood pressure and pulse rate, (3) native Yoruba speakers, and (4) having the ability to walk. Participants were excluded if: (1) they had a history of chest discomfort, angina pectoris, or cardiovascular disease, (2) they had any orthopedic condition affecting their ability to walk, and (3) if they had a history of severe cardiorespiratory disease. Based on the sample size formula for two groups comparison with effect size = 1, power = 0.8, and alpha value = 0.05, the necessary sample size was calculated to be 30.[17] In all, a total number of 35 participants were recruited for the study.

Procedure

Ethical approval for this study was obtained from the Institute of Public Health, Obafemi Awolowo University, Ile-Ife, Nigeria. Written informed consent of participants was obtained, eligibility screening of the participants was conducted,and the height and weight of each participant was measured. Participants were told that they were not obligated to complete the study and that if they experienced symptoms such as shortness of breath, fatigue, or discomfort during the exercise the test would be terminated. Participants watched a demonstration on the treadmill for familiarization prior to the actual test. The order of the test was determined by random drawing. Participants performed 6MTWT first if “A” was drawn or 6MTSWT if it was “B.” Before testing, each participant rested in a chair near the treadmill for 10 minutes. During this period, the blood pressure (BP), heart rate (HR), and oxygen saturation level ($Sp0_2$) of each participant was measured by a digital automatic blood monitor (Omron, M2 Compact(HEM-7102-E(V), Hoofddorp, The Netherlands) and a pulse oximeter (EC-500A, M/s. Swayam Thermometer Industries, New Delhi, India) was fixed at the index finger. Each participant rested for 10 minutes prior to the test and again between the two tests. The music used for the 6MTSWT was the Nigerian nativesong ‘Eye Adaba,’ a Yoruba genre popular among the study population which was familiar to the participants (www.youtube.com/watch?v=_M6xe8jD93w). The song was rendered at 80 beats/min through a headset (BAT music, Model: 5800, Shenzhen, Guangdong, China). The 80bpm was derived from a step conversion chart which convertedthe two-mph speed to 80 steps/min. Participants in this study had no previous singing training.

Six-minute treadmill walk test

Each participant began walking on the treadmill at 2.0 mph for the 6MTWT. The treadmill incline was initially 0% and was increased by 2% every 2 minutes to a maximum exertion of 6%. The test was terminated at the patient’s request if there was evidence of dyspnea, chest pain, diaphoresis, or at the end of the full 6 minutes. The BP, HR, and Sp02 were taken again immediately after the test with the participants sitting.

Six-minute treadmill sing walk test

The 6MTSWT was similarly performed on a powered treadmill at a speed of 2.0 mph. Initial readings of BP, HR, and Sp02 were taken at the start and at the end of the 6MTWT. During the test the treadmill incline was increased by 2% every 2 minutes to a maximum exertion of 6%. Each participant was given a headset and was asked to sing along as the song played. As with the 6MTWT, the test was terminated at the patient’s request if there was evidence of dyspnea, chest pain, diaphoresis, or at the end of the full 6 minutes. Readings were again taken immediately afterward with the participants in a sitting position.

Outcome measurements

The Borg Rating of Perceived Exertion scale, which has a range of 6 to 20 points, was used to assess the Perceived Exertion Rate (RPE) in both tests. In addition, BP, PR, and SpO_2 were measured pre- and post-test while Rate Pressure Product (RPP) and Metabolic Equivalents (METs) were calculated for each participant from the cardiovascular measures. Rate Pressure Product = Systolic Blood Pressure (mmHg) X Heart Rate (bpm).[18,19]

Data analysis

Data were analyzed using descriptive (mean and standard deviation) and inferential statistics. The paired t-test was used to assess the differences between the pre-and post-walk test cardiovascular parameters within each group, while the independent t-test was used to compare the differences in cardiovascular parameters of the participants between the six-minute treadmill walk test and the six-minute treadmill sing walk test. Pearson’s moment correlation coefficients were used to investigate the relationship between the cardiovascular parameters of the two tests. The alpha level was set at $p < 0.05$. Statistical Package for Social Sciences(SPSS) version 23 (Chicago, Illinois, USA) was used for data analysis.

Results

The physical characteristics of the participants are presented in Table 1. The majority (62.86 %) of the participants were male. The mean age and body mass indexes were 22.29±1.36 years and 21.12±2.66kg/m^2. The paired t-test comparison of cardiovascular parameters at baseline and after 6MTWT showed significant differences in SBP, PR, RPP, and PRE ($p < 0.05$). However, there was no significant

Table 1. Physical characteristics of the participants (N=35)

Valiables	(n/%) / $\overline{x}$ (SD)
Gender (male)	22 (62.86)
Age (years)	22.29 (1.36)
Height (m)	1.70 (0.09)
Weight (kg)	61.20 (10.2)
BMI (kg/m^2)	21.12 (2.66)

BMI, body mass index; $\overline{x}$ (SD), mean ± standard deviation; n frequency; % percentage

difference in DBP ($p > 0.05$) (Table 2).

Similarly, the paired t-test comparison of cardiopulmonary parameters at baseline and after 6MTSWT showed significant differences in SBP, RPP, and RPE ($p < 0.05$).With this test, there was no significant difference in DBP or in PR ($p > 0.05$) (Table 2). Table 3 shows an independent t-test comparison of cardiopulmonary responses (mean change) between 6MTWT and 6MTSWT. There was a significant difference in the PR (2.37±3.90 vs. 0.54±3.24: $p = 0.037$) and RPP (776.80±602.24 vs. 483.86±399.28, $p = 0.019$), but there was no significant difference in systolic blood pressure (SBP), diastolic blood pressure (DBP), or RPE values ($p > 0.05$). Table 4 shows the relationship between 6MTWT and 6MTSWT for the cardiovascular parameters using Pearson's Product Moment Correlation Coefficients. The results show a significant correlation between RPP response and distance covered in 6MTSWT only (r = 0.402, $p = 0.017$).

Table 2. Paired t-test comparison of cardiovascular parameters at baseline and after a six-minute treadmill walk test and after six-minute treadmill sing-walk test (N=35)

Valiables	6MTWT				6MTSWT			
	Pre-test $\overline{x}$ (SD)	Post-test $\overline{x}$ (SD)	T	*p-value*	Pre-test $\overline{x}$ (SD)	Post-test $\overline{x}$ (SD)	T	*p-value*
SBP	116.63 (13.3)	123.06 (14.4)	-8.975	0.001*	113.51 (13.3)	119.03 (13.7	-7.334	0.001*
DBP	72.91 (9.40)	71.11 (8.91)	1.482	0.148	74.17 (12.7)	70.89 (12.4	2.827	0.08
PR	74.09 (11.5)	76.46 (12.4)	-3.594	0.001*	76.60 (11.8)	77.14 (12.6	-0.992	0.328
RPP	8641.14 (1655.52)	9417.94 (1932.93)	-7.631	0.001*	8729.34 (1800.72)	9213.20 (1939.64)	-7.169	0.001*
RPE	6.00 (0.00)	9.80 (1.83)	-12.30	0.001*	6.00 (0.00)	9.74 (2.06)	-10.734	0.001*
SpO2	97.80 (1.13)	97.34 (1.16)	----------	--------	97.71 (1.07)	97.63 (1.35)	-----	------
METs	3.89 (0.15)	4.16 (0.15)	---------	-------	3.89 (0.15)	4.16 (0.15)	-------	-------

*indicates a significant difference; SBP, systolic blood pressure (mmHg); DBP, diastolic blood pressure (mmHg); SpO_2, oxygen saturation pressure; PR, pulse rate (bpm); RPP, rate pressure product (mmHg; RPE, rate of perceived exertion; METs, metabolic equivalents of tasks; 6MTWT, six-minute treadmill walk test; 6MTSWT, six-minute treadmill sing-walk test

Discussion

This study compared the effects of 6MTWT and 6MTSWT on cardiovascular parameters in apparently healthy individuals. The study's findings show that slow-tempo singing during 6MTWT significantly decreased the PR and RPP of healthy young individuals. The participants were young, age between 20-25 years, thus eliminating the possible moderating effect of high variability in age on cardiovascular response. Age has been reported to influence cardiovascular response to exercise,[20] including the six-minute walk test.[21]

In this study, both 6MTWT and 6MTSWT led to a significant increase in SBP, RPP, and RPE. The significant increase in SBP in 6MTWT is in accord with previous studies.[22,23] Both tests reduced DBP response; however, the difference between the groups was not statistically significant. Sembulingan and Sembulingan[24] and Stebbins et al.[25] reported that DBP reduces endurance level due to the accumulation of metabolic end products in tissues. Changes in DBP during exercise suggest an unstable form of hypertension related to coronary heart diseases and other heart-related problems, which is affected by

Table 3. Independent t-test comparison of cardiovascular responses (mean change) between the six-minute treadmill walk test and six-minute treadmill sing-walk test (N=35)

Variable	6MTWT $\overline{X}$ (SD)	6MTSWT $\overline{X}$±SD	t	*p*-value
SBP	6.43 (4.24)	5.51 (4.45)	0.880	0.382
DBP	1.80 (7.19)	3.29 (6.87)	0.884	0.380*
PR	2.37 (3.90)	0.54 (3.24)	2.133	0.037*
RPP	776.80 (602.24)	483.86 (399.28)	2.398	0.019*
RPE	3.80 (1.83)	3.74 (2.06)	0.123	0.903

*Indicates a significant difference
SBP, systolic blood pressure (mmHg); DBP, diastolic blood pressure (mmHg); PR, pulse rate (bpm); RPP, rate pressure product (mmHg); RPE, rate of perceived exertion

Table 4. Relationship of the Pearson's Product Moment Correlation Coefficient of cardiovascular parameters between the six-minute treadmill walk test and the six-minute treadmill sing walk test

Variable	6MTWT (distance)		6MTSWT (distance)	
	Pearson moment correlation (r)	p-value	Pearson moment correlation (r)	*p*-value
SBP	0.240	0.164	-0.027	0.878
DBP	0.111	0.526	-0.183	0.294
SPO_2	-0.185	0.288	-0.56	0.748
PR	-0.236	0.173	-0.314	0.067
RPP	-0.015	0.932	-0.402	0.017*
RPE	0.103	0.556	0.290	0.091

*Significant correlation
SBP, systolic blood pressure (mmHg); DBP, diastolic blood pressure (mmHg); SPO_2, oxygen saturation pressure; PR, pulse rate (bpm); RPP, rate pressure product (mmHg); RPE, rate of perceived exertion

body position during exercise and by the type of exercise.[26] The 6MTWT and 6MTSWT tests are both submaximal exercises and therefore are not expected to elicit any significant changes in the participants' DBP, especially as they were young and free from any cardiovascular dysfunction prior to and at the time of recruitment.

The findings of this study show that 6MTWT leads to a significantly higher cardiovascular response in PR and RPP when compared with 6MTSWT. The higher increase in PR during 6MTWT may be explained by the fact that 6MTWT evokes a higher increase in venous return, myocardial contractility, and stimulation of the sympathetic nervous system leading to an increase in blood pressure and more blood going to the exercising muscles, thereby increasing cardiac output and vasodilatation.[23] Participants' lower PR response to 6MTSWT may be attributable to reduced sympathetic outflow during singing.[12] Olsson et al.[27] reported that singing slow songs resulted in slower PR compared to faster songs. The song's tempo used in the study was slow (80 bpm).

The nature of music songs, such as the tempo and phrasing, emerges as a critical element in mediating the effects of singing,[7] and responses to singing provide a mild form of sympathetic stimulation[7] as observed in this study. Because singing can reduce pulse rate, it might also provide the added benefit of reducing patients' susceptibility to ischemia. Studies have reported that any activity or factor that can shorten the diastolic phase of the cardiac cycle, such as increasing PR, will impair the supply of blood to the subendocardium, rendering that region more susceptible to ischaemia.[28,29]

Change in RPP was found to be significantly lower in 6MTSWT than in 6MTWT. RPP is a valuable marker of the oxygen requirement for the heart to function. The heart, being a muscular organ, needs a steady supply of oxygen and nutrients for effective functioning.[30] A deficient supply of these elements increases the likelihood of heart problems.[31] The significant reduction of RPP among the participants during 6MTSWT in this study suggests that it may aid the successful rehabilitation of patients with cardio-respiratory problems and may also help reduce the incidence of those problems in patients with risk factors for developing cardio-respiratory dysfunctions.

The findings of this study show that slow-tempo singing might alter cardiovascular parameters positively and may clinically help patients with cardiovascular diseases, e.g., hypertension. This finding appears to be relevant for cardiovascular patients as the test protocol (6MTSWT), a sub-maximal test, is generally tolerated by this group of patients. However, despite the potential clinical implications, this study has some potential limitations. One limitation is that the study was carried out among young, apparently healthy individuals, so the generalizability of the findings to older adult populations may be limited. Furthermore, cardiovascular response to the walk and sing-walk tests lasting for either shorter or longer periods may give different results than those observed in this study. Lastly, we did not analyze the period, carryover, and sequence effects which may potentially have affected the study findings. Further studies of the efficacy of 6MTSWT in individuals with varied demographics and different patients populations, especially those with cardiovascular diseases, are warranted.

Conclusion

Slow-tempo singing decreases PR and RPP significantly during 6MTWT in healthy young individuals.

Disclosure

There are no conflicts of interest to disclose

References

1. American Thoracic Society (ATS) statement. Guidelines for the six-minute walk test. Am J Respir Crit Care Med [Internet]. 2002 March [cited 2022 Dec 10]; 166:111–7. Available from:https://www.atsjournals.org/ doi: 10.1164/ajrccm.166.1at1102
2. Laskin JJ, Bundy S, Marron H, Moore H, Swanson M, Blair M, Humphrey R. Using aTreadmill for the 6-Minute Walk Test. Cardiopulm Rehabil Prev [Internet]. 2007 Nov [cited 2023 Jan 3]; 27(6):407-10. Available from: https://pubmed.ncbi.nlm.nih.gov/18197077/ doi: 10.1097/01.HCR.0000300270.45881.d0
3. Palackic A, Abazie S, Parry I, Sen S, Mlcak RP, Lee JO, et al. Comparison of a six-minute walk and modified Bruce treadmill tests in Pediatric patients with severe burns: A Crossover Study. J Rehabil Med [Internet]. 2022 Oct [cited 2023 Jan 2]; 19 (54):jrm00305.Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9593470/ doi: 10.2340/jrm.v54.1064
4. Stevens D, Elpern E, Sharma K, Szidon P, Ankin M, Kesten S. Comparison of hallway and treadmill. Am J Respir Crit Care Med [Internet]. 1999 Nov [cited 2022 Oct 11]; 160 (5 Pt 1):1540-3. Available from: https://www.atsjournals.org/ doi: full/10.1164/ajrccm.160.5.9808139
5. Adedoyin RA, Adeyanju SA, Balogun MO, Akintomide AO, Adebayo RA, Akinwusi PO, et al. Assessment of exercise capacity in Africans with chronic heart failure using six minute walk test. Int J Gen Med [Internet]. 2010 Apr [cited 2022 Sep 2]; 3:109-13. Available from: https://pubmed.ncbi.nlm.nih.gov/20463828/ doi: 10.2147/ijgm.s5533
6. Olper L, Cervi P, Santi FD, Meloni C, Gatti R. Validation of the treadmill six-minute walk test in people following cardiac surgery. Phys Ther [Internet]. 2011 Apr [cited 2022 Nov 27]; 91(4):566-76. Available from:https://academic.oup.com/ptj/article/91/4/566/2735056/ doi: 10.2522/ptj.20100156
7. Bernardi NF, Snow S, Peretz I, Perez HDO, Sabet-Kassouf N, Lehmann A. Cardiopulmonary optimization during improvised singing and toning. Sci Rep [Internet]. 2017 Aug [cited 2022 Nov 2]; 7: 8113. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5556092/ doi: 10.1038/s41598-017-07171-2
8. Edworthy J, Waring H. The effects of music tempo and loudness level on treadmill exercise. Ergonomics [Internet]. 2006 Feb [cited 2022 Dec 12]; 49(15). Available from: https:www.tandfonline.com/ doi: abs/10.1080/00140130600899104
9. Eliakim M, MeckelY, Nemet D, Eliakim A. The effect of music during warm-up on consecutive anaerobic performance in elite adolescent volleyball players. Int J Sports Med [Internet]. 2007 Apr [cited 2023 Jan 2]; 28(4):321-5. Available from: https://pubmed.

ncbi.nlm.nih.gov/1702425/ doi: 10.1055/s-2006-924360
10. Bernardi L, Porta C, Sleight P. Cardiovascular, cerebrovascular and respiratory changes induced by different types of music in musicians and non-musicians: The importance of silence. Heart [Internet]. 2006 Apr [cited 2022 Aug 24]; 92(4):445-52. Available from: https://heart.bmj.com/content/92/4/445/ doi: 10.1136/hrt.2005.064600
11. Grape C, Sandgren M, Hansson LO, Ericson M, Theorell T. Does singing promote well-being? An empirical study of professional and amateur singers during a singing lesson. Integr Physiol Behav Sci [Internet]. 2003 Jan [cited 2022 Dec 1]; 38(1):65-74. Available from: https://psycnet.apa.org/record/2003-05812-005/ doi: 10.1007/BF02734261
12. Vickhoff B, Helge M, Rickard Z, Gunnar N, Seth-Reino E, Mathias E, et al. Music structure determines heart rate variability of singers. Front psycho [Internet]. 2013 Jul [cited 2022 Aug 22]; 4:334. Available from: https://www.frontiersin.org/articles/ doi: 10.3389/fpsyg.2013.00334
13. Szmedra L, Bacharach DW. Effect of music on perceived exertion, plasma lactate, norepinephrine and cardiovascular hemodynamics during treadmill running. Int J Sports Med [Internet]. 1998 Jan [cited 2022 Sep 10]; 19(1):32-7. Available from: https://europepmc.org/article/med/9506797/ doi: 10.1055/s-2007-971876
14. Dyrlund AK, Wininger SR. The effects of music preference and exercise intensity on psychological variables. J Music Ther [Internet]. 2008 Jul [cited 2023 Jan 3]; 45(2): 114-34. Available from: https://pubmed.ncbi.nlm.gov/18563969/ doi: 10.1093/jmt/45.2.114
15. Mohammadzadeh H, Tartibiyan B, Ahmadi A. The effects of music on the perceived exertion rate and performance of trained and untrained individuals during progressive exercise. Phys Edu Sport [Internet]. 2008 Jan [cited 2022 Aug 21]; 6(1):67-74. Available from: https://oa.mg/work/16141754
16. Stegemoller EL, Radig H, Hibbing P, Wingate J, Sapienza C. Effects of singing on voice respiratory control and quality of life in persons with Parkinson's disease. Disabil Rehabil [Internet]. 2017 Mar [cited 2022 Dec 2]; 39(6): 594-600. Available from: https://pubmed.ncbi.nlm.gov/26987751/ doi: 10.3109/09638288.2016.1152610
17. Machin D, Campbell MJ, Tan SB, Tan SH. Sample size for clinical, laboratory and epidemiology studies. 4th ed. Oxford: Blackwell Science; 2018.
18. Ansari M, Javadi H, Pourbehi M, Mogharrabi M, Rayzan M, Semnani S, et al. The association of rate pressure product (RPP) and myocardial perfusion imaging (MPI) findings: a preliminary study. Perfusion [Internet]. 2012 Feb [cited 2022 Aug 12]; 27(3):207-13. Available from: https://journals.sagepub.com/ doi: 10.1177/0267659112436631
19. Jette M, Sidney K, Blumchen G. Metabolic equivalents (METS) in exercise testing, exercise prescription, and evaluation of functional capacity. Clin Cardiol [Internet]. 1990 Aug [cited 2022 Nov 19]; 13(8):555-65. Available from: https://onlinelibrary.wiley.com/ doi: 10.1002/clc.4960130809
20. McGuire DK, Levine BD, Williamason JW, Snell PG, Blomqvist CG, Saltin B, et al. A 30-year follow-up of the dallas bedrest and training study: I. Effect of age on the cardiovascular response to exercise. Circulation [Internet]. 2001 Sep [cited 2022 Aug 17]; 104(12):1350-7. Available from: https://www.ahajournals.org/ doi: 10.1161/hc3701.096099
21. Chetta A, Zanini A, Pisi G, Marina A, Tzani P, Neri M, et al. Reference values for the 6-min walk test in healthy subjects 20-50 years old. Respir Med [Internet]. 2006 Sep [cited 2022 Dec 11]; 100(9):1573-8. Available from: https:www.sciencedirect.com/science/article/pii/S0954611106000060/ doi: 10.1016/j.rmed.2006.01.001
22. Rajak PS, Malwade M, Khatri SM, Kathariya N. Effect of 6 minute walk test on cardiac parameters in pediatric age group. IOSR J Nurs Health Sci[Internet]. 2012 Nov [cited 2022 Dec17]; 1(1):49-52. Available from: https://www.iosrjournals.org
23. Vibhuti KS, Mugdha O, Veena K. Response to 6 minute walk test in Healthy adults. Int J Physiother. 2015;2:967-71. doi: /10.15621/ijphy/2015/v2i6/80755.
24. Sembulingam, K, Sembulingam P. Essentials of medical physiology. 5th ed. New Delhi: Jaypee Brother Medical Publishers (p); 2012. p. 638-9.
25. Stebbins C, Walser B, Jafarzadeh M. Cardiovascular responses to static and dynamic contraction during comparable workloads in humans. Am J Physiol Regul Integr Comp Physiol [Internet]. 2002 Sep [cited 2022 Dec 2]; 283 (3):R568-75. Available from: https://journals.physiology.org/ doi: /abs/10.1151/ajpregu.00160.2002
26. Akhras F, Upward J, Jackson G. Increased diastolic blood pressure response to exercise testing when a coronary artery disease is suspected. An indication of severity. BR Heart J [Internet]. 1985 Jun [cited 2023 Jan 2]; 53(6):598-602. Available from: https://heart.bmj.com/content/heartjnl/53/6/598/ doi: 10.1136/hrt.53.6.598.
27. Olsson E, Von Scheele B, Theorell T. Heart rate variability during choral singing. MMD [Internet]. 2013 Feb [cited 2022 Oct 20]; 5(1): 52-9. Available from: https://mmd.iammonline.com/index.php/musmed/article/view/MMD-2013-5-1-8/ doi: 10.47513/mmd.v5i1.197
28. Neil WA, Oxendine J, Phelps N, Anderson RE. Sub-endocardial ischemia provoked by tachycardia in conscious with coronary stenosis. Am J Cardiol [Internet]. 1975 Jan [cited 2022 Sep 1]; 35(1):30-6. Available from: https://pubmed.ncbi.nlm.gov/1109244/ doi: 10.1016/0002-9149(75)90555-x
29. Furchgott RF. Role of endothelium in responses of vascular smooth muscle. Circ Res [Internet]. 1983 Nov [cited 2022 Nov 18]; 53(5):557-73. Available from: https://www.ahajournals.org/ doi: 10.1161/01.RES.53.5.557
30. K. Sembulingam and Prema Sembulingam. Essentials of medical physiology. 6th ed. New Delhi: Jaypee Brothers Medical Publishers; 2012. p. 603.
31. Selwyn A, Braunwald E, Ischemic heart disease in Harrison's principles of internal medicine. In: Isselbacher KJ, Martin JB, Braunwald E, Fauci AS, Wilson JD, Kasper DL, editors. New York: McGraw-Hill; 1994. p. 1081.