Metabolic and Cardiovascular Responses to External Weights During Treadmill Walk in Overweight Young Adults

Swapnil Bhirange[1], Dalia Biswas[2], Avinash Taksande[3], Prerana Agarwal[1]

[1]Assistant Professor, [2]Professor and Head, [3]Associate Professor, Department of Physiology, JNMC, Sawangi (Meghe), Wardha

Abstract

Aim and Objective: Compare the physiological responses within bouts of aerobic exercise varying in intensity and the presence of wearable weights.

Study Design: Interventional study

Settings: Exercise Physiology Lab at the department of Physiology, JNMC, Sawangi (Meghe), Wardha.

Method and Material: Forty (18 females, 22 males, mean age = 22.23 ± 1.32) healthy volunteers were tested for aerobic fitness on a treadmill to determine VO2. Participants completed eight 30-minute walking trials on a treadmill and oxygen consumption (VO2) and heart rate (HR) were monitored while walking at different speeds and with varying combination of upper and lower body external weights. The design included two intensities (slow walking and brisk walking) and four conditions (no weights, arm weights, leg weights, and arm and leg weights) for a total of eight experimental trials.

Statistical Analysis Used: ANOVA and pair-wise comparisons on SPSS software version 24.

Results: VO2 was significantly lower without the wearable weights in comparison to wearing both upper and lower weights in the slow walk trial ($P < 0.001$; ES = 0.74) and also during the brisk walk trial ($P < 0.001$; ES = 0.35). HR was significantly higher during the brisk walk trials with external weights on both the arms and legs (P=0.018, ES=0.37).

Conclusions: Findings suggest that the metabolic responses were significantly increased wearing external weights on both the arm and leg during walking exercise on treadmill and increasing energy expenditure (burning additional calories) over the 30 minute session and have minimal impact on heart rate.

Keywords: *External weights, VO_2Max, Heart rate, treadmill.*

Introduction

Obesity has become one of the major health issues over the world. Worldwide obesity has nearly tripled since 1975. In 2016, more than 1.9 billion adults, 18 years and older, were overweight. Of these, over 650 million were obese. 39% of adults aged 18 years and over were overweight in 2016, and 13% were obese.[1]

Overweight and obesity have become the major health problem, in addition to physical inactivity, in almost all the age groups particularly in urban areas with serious medical and psycho-social consequences, replacing the more traditional public health concerns. Though low prevalence of obesity among Indian children (3-2%) may be surprising, but the relatively high prevalence of overweight (14-9%) is alarming.[2]

Overweight children often become overweight adults[3] and overweight in adulthood is a health risk. Large cohorts from various populations have demonstrated the important influence of childhood BMI on future cardiovascular health. Juvenile obesity is particularly alarming because it is considered to be a key predictor for obesity in adulthood[4], and its prevention and treatment have a remarkable clinical relevance [5]. Several disorders have been linked to overweight and obesity in childhood. Obesity results in considerable morbidity and mortality, of which cardiovascular disease and type 2 diabetes mellitus remains one of the principal causes.[2]

Physical activity has been the integral part of human body and it should naturally be part of our everyday life. Because of a more modern and demanding lifestyle, physical activity has declined, becoming less important than other activities such as work, family, or social responsibilities. Regular physical activity is associated with various health benefits. Active individuals can lower their risk of coronary heart disease, hypertension, colon cancer and diabetes by being active for thirty minutes a day. Exercise also helps maintain a healthy weight, stronger bones, muscles and joints, reduce body fat and increase lean muscle. Also regular exercise can decrease anxiety and depression while improving mood[6].

Methodology

Study design: Interventional study

Settings: Neurophysiology Lab at the department of Physiology, JNMC, Sawangi (Meghe), Wardha.

Participants: 40 participants (22 boys and 18 girls) ranging from 18-25 years were recruited. Each participant was asked to walk on the treadmill to determine the exercise intensities for subsequent exercise trials.

Familiarization with the external weights included instruction on proper size, location, and fit for the ankles and wrists. The purpose of this portion of the trial was to provide exposure to the external weights prior to the experimental manipulation to limit the perceptual impact of wearing a novel device.

Following setting workload and familiarization, the participants was informed about the exertion assessment scale that was to be used throughout the research study. Borg's 6-20 Rating of Perceived Exertion scale (RPE) [7] was explained in full detail to each participant, and the participants were then required to confirm that they understood the tool clearly.

Sample size: Sample size was calculated as fourty (40) using formula $4PQ/L^2$ where prevalence of overweight adults has been taken as 11.3% [8]

Description of Laboratory Visits:

Visit Description:

1. Screening to include a physical exam, informed consent, and resting assessments
2. Maximal treadmill test
3. Setting Workload and Familiarization with treadmill and external weights
4. 4-7 Experimental exercise trials

Screening (Visit 1): The screenings included a comprehensive health history, pre-participation physical exam administered by a physician, completion of the informed consent document, and assessment of resting heart rate, weight, height, and blood pressure.

Maximal Exercise Testing (Visit 2): Each participant was complete a graded exercise maximal treadmill test that included measurements of heart rate, blood pressure, perceived exertion, and metabolic gas exchange. The "Health and Exercise Science (HES)" protocol[9] was used for this test consists of a starting speed of 3.0mph on the treadmill with speed increases of 0.5 every minute afterward. Heart rate and RPE were recorded every minute; blood pressure was recorded every three minutes. When participants reached a speed of 7.0 (females) or 8.0 (males) on the treadmill, the incline was then increased by 2% every minute thereafter, with no additional increases in speed. Participants were encouraged to go until maximal effort and exhaustion was achieved.

Setting Workload and Familiarization (Visit 3): Each participant was asked to walk on the treadmill to determine the exercise intensities for subsequent exercise trials.

One workload corresponds to a "slow walk" which was designed to replicate walking that was associated with activities of daily living.

The second workload corresponds to a "brisk walk" which was designed to replicate walking that was purposeful and associated with fitness. Workload establishment of the two separate speeds lasted approximately 30 minutes with 15 minutes designated to each walking speed. Collectively, the two workloads were self-selected and were intended to reflect public health recommendations related to lifestyle physical activity.

Familiarization with the external weights included instruction on proper size, location, and fit for the ankles and wrists (3 Kgs, **AURION** Wrist/Ankle External weights Home Gym Weight Bands commercially available on **AMAZONE**) [10, 11]. The purpose of this portion of the trial was to provide **exposure to the external weights prior to the experimental manipulation to limit the perceptual impact of wearing a novel device**. Following setting workload and familiarization, the participants were informed about the exertion assessment scale that was to be used throughout the research study. Borg's 6-20 rating of perceived exertion scale (RPE) was explained in full detail to each participant, and the participants were then required to initiate that they understood the tool clearly.

Experimental Exercise Trials (Visits 4-7): The four experimental trials were allowed for both exercise intensities to be tested across four equipment conditions. The two exercise intensities examined were the "**slow walk**" and "**brisk walk**". The four equipment conditions included: no external weights, ankle and wrist external weights, wrist external weights only, and ankle external weights only (see Table).

Prior to each exercise trial, the metabolic cart was properly calibrated by the research team. A heart rate monitor was supplied for each participant upon arrival to the laboratory. A warm-up of 30 seconds was preceded every exercise trial at a speed of 2.5 mph on the treadmill. At the conclusion of the warm-up, the speed was adjusted to either to a self- selected "slow" or "brisk" walking pace as previously determined, and was dependent upon what condition the participant will be assigned for that day. Every six minutes heart rate and rate of perceived exertion for the ankles, chest/breathing, and overall were assessed. At minute 24 of the exercise trial maximal heart rate achieved and perceived exertion of the ankles were recorded from minute 24 to minute 29 at an interval of 1min.

At 30 minutes, a 30 second cool down at 2.5mph on the treadmill was transpired. Once the treadmill was stopped by the research team, immediate post exercise perceived exertion was taken and again ten minutes afterwards.

Thus Heart rate and oxygen consumption were investigated across self- selected two intensities (slow and brisk) with four different combinations of External weights (Table 1) and eight balanced experimental trials (walking for thirty minutes at a self- selected slow or brisk speed with either no togs, arms only, legs only, or both arm and leg togs) were incorporated.

Table 1: Experimental Trial Conditions

Intensity		External weights			
Slow Walk	Brisk Walk	None	Wrist & Ankle	Ankle Only	Wrist Only

Inclusion Criteria:

- Age between 18-25 years
- BMI 23 – 24.9 kg/m^2 [12]
- Participants not doing regular physical exercise
- Participants giving consent

Exclusion Criteria:

- Age between <18 and >25 years
- BMI between < 22.9 and >25 kg/m^2
- Participants having cardiovascular, metabolic, pulmonary diseases and related symptoms
- Participants doing regular exercise
- Patients not following the guidelines of this study
- Participants not giving consent

Outcome Measures:

- Cardiovascular – Heart rate
- Metabolic - VO_{2max}

Statistical Data Analysis: The research design utilized two intensity namely slow walk and vigorous walk and four conditions namely no external weights, wrist and ankle-external weights, ankle-external weights only, wrist-external weights only. Repeated measures ANOVA test for statistical analysis was applied. Each participant served as their own control. Each p-value will be<0.05.

Results

Table 2: Demographic profile of the participants (n = 40)

	Minimum	Maximum	Mean ± SD
Age	18	25	22.23±1.32
Height (inch.)	59	71	64.84±2.11
Weight (lbs.)	116	194	161.0±23.9
BMI	23.82	24.87	24.35±0.65
Slow speed	1.8	3.1	2.45±0.55
Brisk speed	3.2	4.6	3.91±0.70

Table 3: $VO2_{max}$ Data: Descriptive statistics (n = 40)

Treadmill speed–external weights	Mean ± SD
Slow-none	12.11 ± 1.43
Slow-arms	12.81 ± 1.45
Slow-legs	11.98 ± 1.81
Slow-both	12.83 ± 1.42
Brisk-none	14.97 ± 2.12
Brisk-arms	15.64 ± 2.32
Brisk-legs	15.92 ± 1.98
Brisk-both	16.12 ± 2.69

Table 4: Follow-up Comparisons (VO2)

Variable 1	Variable 2	P-value	Effect Size
Brisk-none	Brisk-both	<0.001	0.35
Brisk-none	Brisk-arms	0.876	0.39
Brisk-none	Brisk-legs	0.006	0.34
Brisk-both	Brisk-arms	0.001	0.56
Brisk-both	Brisk-legs	0.372	0.98
Brisk-arms	Brisk-legs	0.001	0.76
Slow-none	Slow-both	<0.001	0.74
Slow-none	Slow-arms	0.546	0.09
Slow-none	Slow-legs	0.008	0.33
Slow both	Slow-arms	<0.001	0.34
Slow-both	Slow-legs	0.006	0.87
Slow-arms	Slow-legs	0.328	0.45

The results showed that comparison between "VO2 during the "slow" walk with and without external weights on the **arms**." (p=0.546); "VO2 during the "brisk" walk with and without external weights on the **arms**" (p=0.876); "VO2 during the "brisk" walk with external weights on both the **arms and legs** and that with external weights on the **legs only**" (p=0.372); and "VO2 during the "slow" walk with external weights on the **arms** that with external weights on the **legs**" (p=0.328) had no significant difference.

But the results showed that comparison between "VO2 during the "slow" walk with and without external weights on the **legs**" (p=0.008); "VO2 during the "brisk" walk with and without external weights on the **legs**" (p=0.006); "VO2 during the "slow" walk with and without external weights on both the **arms and legs**" (p<0.001); "VO2 during the "brisk" walk with and without external weights on both the **arms and legs**" (p<0.001); "VO2 during the "slow" walk with external weights on both the **arms and legs** that with external weights on the **arms only**" (p<0.001); "VO2 during the "brisk" walk with external weights on both the **arms and legs** and that with external weights on the **arms only**" (p=0.001), and lastly "VO2 during the "slow" walk with external weights on both the **arms and legs** and VO2 during the "slow" walk with External weights on the **legs only**" (p=0.006) showed a significant difference.

Heart Rate:

Table 5: HR Data: Descriptive statistics (n = 40)

Condition	Mean±SD
Slow-none	96.87±10.34
Slow-arms	97.23±12.01
Slow-legs	108.89±8.25
Slow-both	103.26±14.980
Brisk-none	116.87±11.89
Brisk-arms	117.12±10.87
Brisk-legs	119.11±14.68
Brisk-both	119.95±13.48

Table 6: Follow-up Comparisons (Heart Rate)

Variable 1	Variable 2	P-value	Effect Size
Brisk-none	Brisk-both	0.018	0.37
Brisk-none	Brisk-arms	0.656	0.23
Brisk-none	Brisk-legs	0.002	0.26
Brisk-both	Brisk-arms	0.044	0.65
Brisk-both	Brisk-legs	0.621	0.81
Brisk-arms	Brisk-legs	0.035	0.19
Slow-none	Slow-both	0.003	0.21
Slow-none	Slow-arms	0.629	0.96

Variable 1	Variable 2	P-value	Effect Size
Slow-none	Slow-legs	0.041	0.65
Slow both	Slow-arms	0.034	0.21
Slow-both	Slow-legs	0.214	0.36
Slow-arms	Slow-legs	0.023	0.73

The results showed that comparison between "heart rate during the "slow" walk with and without external weights on the **arms**." (p=0.629); "heart rate during the "brisk" walk with and without external weights on the **arms**" (p= 0.656); "heart rate during the "brisk" walk with external weights on both the **arms and legs** and that with external weights on the **legs only**" (p= 0.621); and "heart rate during the "slow" walk with external weights on the **arms** that with external weights on the **legs**" (p=0.083) had no significant difference.

But the results showed that comparison between "heart rate during the "slow" walk with and without external weights on the **legs**" (p= 0.041); "heart rate during the "brisk" walk with and without external weights on the **legs**" (p= 0.002); "heart rate during the "slow" walk with and without external weights on both the **arms and legs**" (p<0.003); "heart rate during the "brisk" walk with and without external weights on both the **arms and legs**" (p<0.019); "heart rate during the "slow" walk with external weights on both the **arms and legs** that with external weights on the **arms only**" (p< 0.034); "heart rate during the "brisk" walk with external weights on both the **arms and legs** and that with external weights on the **arms only**" (p= 0.044), "heart rate during the "slow" walk with external weights on **arms only** and that with external weights on the **legs only**" (p=0.023) and lastly "heart rate during the "brisk" walk with external weights on **arms only** and that with external weights on the **legs only**" (p=0.035) showed a significant difference.

Discussion

The present experiment is designed to examine the cardiovascular and metabolic responses of walking with external weight worn on the wrists and ankles. Results showed a significant increase in oxygen consumption while wearing External weights during exercise. Wearing these additional weights while walking elicited a linear rise in oxygen consumption, and more specifically, the largest responses were seen during trials with External weights on both the arms and legs.

An approximate 13% increase in energy cost was seen during the "slow" walk when both sets of external weights were added to the body while about 16 extra calories were burned throughout the walking trial. Furthermore, about 12% increase in energy cost was also seen when adding arm and leg external weights during the "brisk" trials. When walking at a "brisk" speed with no external weights, participants burned, on average, about 184 calories. When arm and leg External weights were added, it resulted in an average of 23 more calories burned over thirty minutes. But there was a little change in heart rate while wearing External weights. From resting heart rate to maximal heart rate, heart rate increased about four times, and the resting oxygen consumption had increased up to sixteen times during the brisk walking trials. Thus the significant increase in heart rate is relatively difficult to see. It still suggested the metabolic adjustments produced by the addition of External weights. [10] There was significant increase in heart rate and oxygen consumption with wrist weights, explaining that walking with wrist weights increased the energy cost more than the ankle weights.

Wearing external weights during exercise by an overweight individual can easily overcome the discouragement he/she experiences from the amount of maintenance required to stay healthy and fit leading to higher self-efficacy in the exerciser. This also prevents further weight gain by making small increases in physical activity.

As we are solely looking at a low-risk healthy population of young adults ranging 18years to 25years, therefore the findings cannot be generalized to other groups such as the elderly, adolescent or hypertensive. Thus we recommend for further research on individuals with different fitness levels and using a more intense exercise modality like running or cycling. Also, the External weights implicate small changes for those individuals who are sedentary, and may not provide a large metabolic response due to the little amount of weight that they add. Therefore, it is difficult to consistently report such a sensitive amount of change in oxygen consumption.

Conclusion

The metabolic responses were significantly increased wearing external weights on both the arm and leg during walking exercise on treadmill and burn additional calories over the 30 minute session, eliciting an approximate 12% improvement over exercise sessions when no external weights were worn. Significant increase in oxygen consumption and caloric expenditure was observed by wearing the external weights, but the cardiovascular responses were not significant at both the slow and brisk speeds. External weights can thus be a practical and promising tool to be implemented into the fitness industry and rehabilitation centers.

Ethical Clearance: Taken from institutional ethics committee.

Source of Funding: Self.

Conflict of Interest: Nil.

References

1. Serdula M et al. Do obese children become obese adults? a review of the literature. Prev Med 1993; 22:167-177
2. Goran M. Metabolic precursors and effects of obesity in children: a decade of progress, 1990–1999. Am J ClinNutr 2001: 73: 158–171
3. Lafortuna C et al. Metabolic responses to submaximal treadmill walking and cycle ergometer pedalling in obese adolescents. Scand J Med Sci Sports 2010: 20: 630–637
4. Pate R et al: Physical activity and public health: recommendation from the Centers for Disease Control and Prevention and the American College of Sports Medicine. JAMA 273, 402-407
5. Rajendra Pet.al. Prevalence of generalized & abdominal obesity in urban & rural india- the icmr-indiab study (phase-i) [icmr-indiab-3]; Indian J Med Res. 2015; 142: 139-150
6. Graves J et al. The effect of hand-held weights on the physiological responses to walking exercises. Medicine & Science in Sports & Exercise. 1987; (19)3: 260-5.
7. Behl S et al. Management of obesity in adult Asian Indians. Indian Heart J. 2017; 69 (4):539–544.
8. Kyle R et al. Physiological and biomechanical responses of highly trained distance runners to lower-body positive pressure treadmill running. Barnes and Janecke Sports Medicine – Open 3:41
9. Engels H et al. Metabolic and hemodynamic responses to walking with shoulder-worn exercise weights: a brief report. Clinical Journal of Sports Medicine. 1995; (5)3: 171-4.
10. Graves, J et al. Physiological responses to walking with hand weights, wrist weights and ankle weights. Medicine & Science in Sport & Exercise, 1988; 20(3), 265-71.
11. Bastien G et al. Effect of load and speed on the energetic cost of human walking. Eur J Appl Physiol. 2005; 94: 76–83.