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Original Article

Effect of endurance training with weighted vest on the 3000 meter running time of high school boys

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Abstract:
The purpose of this study was to determine the effect of different approaches, particularly Endurance Training (E), Endurance and Strength Training (EST) and Endurance Training with weighted vest (EWV) to the 3000-meter running time of adolescent boys. Twenty-six (N=26) young male participants underwent interventions in between two observations. Pre-test included a 3000-meter time trial in mass start, 20-meter Multistage Test and Body Fat Analysis using a handheld device. Results showed significant difference between pre-test and post-test scores of EWV in the 3000-meter running time. Despite no exhibited significant change among EST and E group, all scores from three methods were directed towards decreasing running time. Change in VO_2max among the three groups is significant only for groups with strength-training protocols.
Key Words*:* - Endurance training, strength training, running time, VO_2max

Introduction

In competitive sports, monitoring endurance of athletes in the course of training period is essential in achieving goals and optimal performance. Level of endurance predicts the execution of quality performance especially at the latter part of every match where athletes exert their final effort to win.

Adaptation occurs in months of training to promote the appropriate energy system and cellular level activity, and oxygenation of skeletal muscles that will highly utilize fat (Coggan et al, 2000; Tolfrey et al, 2000) and amino acids. Detraining effects however occur in 12 days of inactivity and VO_2max drops 7% from the previously trained level. During this early period, a rough decline of citrate synthase and succinate dehydrogenase is found, both essential for ATP production. This decrease of activity still continued up to the 56th day. VO_2max was merely affected by the increased heart rate and 10-14% drop in stroke volume (Coyle et al, 1984).

In all performance parameters including endurance, exceptional attention is given to the physiological development of adolescents. A study on adolescents still exhibit related training improvements with other age-groups, exhibiting a 5 to 6% improvement in VO_2peak when subjected to endurance and aerobic training (Baquet et al, 2003).

ATP production, including factors that maximize this production process, has been the guiding theory in the study of endurance in the cellular level. Pioneers (Davies, 1981; Holloszy, 1967) have explored the biochemical effects of exercise to muscles and mitochondria, including the activity of respiratory enzymes during endurance training. It is directly presented how in these studies endurance training and mitochondrial development of an organism are related. Oxidative capacity was also found to be correlated with this endurance capability.

The rate of ATP production in the mitochondria with endurance training was investigated supporting previous works that endurance training significantly increase ATP production rate in the mitochondria (Wibom et al, 1992), with polygenic profile as a factor in dictating suitability for mitochondrial biogenesis (Eynon et al, 2011). The link between muscle oxidative capacity and mitochondrial content has been expressed also in terms of protein signals as found in the work of Gollnick (1984). Expression of PGC-1α has been found to be a factor in mitochondrial biogenesis (Kong et al, 2010; Aquilano et al, 2010; Austin &St.Pierre, 2012), increasing mitochondrial enzyme activity in the ATP production process, and driven specifically by endurance exercise (Popov et al, 2014; Little et al, 2010).

The concept of greater exercise stress (Holloszy, 1967) in endurance training found a significant increase in the activity of cytochrome-c oxidase and succinate dehydrogenase, two enzymes crucial for ATP production in the mitochondria. Greater intensity in endurance training yields to an increase in aerobic power, decreases stress and anxiety (Norris, Carroll & Cochrane, 1992), and associated with increases in maximal cardiac output, stroke volume and vascular conductance. This is expressed in a study (Makrides et al, 1990)

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where young men, age 20-30, increase VO_2peak to 29%, surpassing 5-6% increase from the adolescent group (Baquet et al, 2003).

Strength Training in Endurance

Strength training has been found to be beneficial for children and adolescents not only in skills but in wellness as well. It improves motor skills, body composition and bone health (in Brooks, 2005). Improvement in body composition highlights on increasing fat-free mass and decreased fat mass. Reviews have also presented positive correlation between resistance training and growth hormone induction. Though this finding needs further studies to verify, strength training has been relatively safe and a healthy practice among children and adolescents (Barbieri &Zaccagni, 2013).

Practitioners have highlighted muscle hypertrophy in strength training and how endurance training affects this specific adaptation when incorporated to the program (Ronnestad, Hansen & Raastad, 2012). However, Anderson (2011) discussed in the book of Cardinale how the molecular mechanism of hypertrophy in the course of concurrent endurance and strength training is taking effect. Translation factors in protein synthesis are activated by mechanistic target of rapamycin or mTOR system. Triggered by IGF-1 and regulated by the availability of glycogen and amino acids, mTOR increases translation initiation and protein synthesis after resistance exercise. By the time glycogen reached low concentration, adenosine monophosphate (AMP) concentration increases, inhibiting the activity of mTOR. This leads to discontinuation of protein synthesis, later, limiting hypertrophy during concurrent endurance and strength training.

Among the different participants of various training programs, it is evident that novices draw greater adaptation from exercise programs because of the novel stimulation given to the body. Significant physiological responses to new stimuli are the body's mechanism to survive and relate with factors found in the environment. A recent study (Davitt et al, 2014) also shows that this phenomenon happens, even in non-adolescent and female participants. A recent study done by the group of Taipale (2013) explored on neuromuscular adaptations from different modalities including maximal strength training (MAX), explosive training (EX) and body weight circuit training (CON), and its effect on different factors such as maximal running speed ($S_{peak)}$, respiratory compensation threshold (RCT) and maximal oxygen uptake. They found no significant increase in speed after 8 weeks for the MAX and CON, consistent to other findings (Smrkolj and Skof, 2013) about the effects of maximal strength training on muscle fiber composition. On the other hand, increase in S_{peak} was found in EX. Results also validated findings of Makrides on the improved VO_{2peak} in 1990. The study of Sawyer (2014) also suggests that improvements in endurance performance from strength training have anaerobic work capacity as a better predictor ($p<0.05$), with 7.9% at VO_2peak increase in power (Sawyer et al, 2014; Harries, Lubans & Callister, 2012). Concurrent endurance and strength training has been observed to innovate and develop training methods in terms of 3000-meter running performance. Kelly (2008) found this trend with greater improvement in running time when integrating strength training to endurance exercise. On the other hand, significant improvements ($p<0.05$) in force-time and anaerobic performance were associated to endurance with explosive strength training (Mikkola et al, 2007).

Weighted Vest- In 2010 at Wichita State University, researchers examined the effect of weighted vest worn during warm-up of high school male football players. They found no significant difference between leg power performance of control and treatment groups using Margaria-Kalamen Power Test. Results, however, left questions on how greater-intensity aerobic training augments aerobic power and endurance performance results when it comes to adolescent males (Reiman et al, 2010). In the study of Faigenbaum and his associates (2006) done years ago, they used high school female participants instead of males. Four dynamic warm-up protocols with weighted vest were employed and tested its effect on leg power and performance. Among the four protocols, the researcher identified that dynamic warm-up with 2% body mass vest may give significant improvements in power of lower extremities. In relation to Reiman's (2010), the study also did not give generalizations about endurance performance. Aside from effects on power, weighted vest has been used in studying training outcomes on running speed. Rantalainen, Ruotsalainen and Virmavirta (2012) found improvements ($p=0.016$) in running time using the figure-8 test. Participants have a mean age of 32, exclusively done in males. Researchers recommended proper volume and intensity to be done in 3-4 weeks to elicit different results. However, running speed variable is limited to short durations and specific to speed with agility and not to long durations and endurance performance.

It is theorized that both method, Resistance (Sawyer et al, 2014) and Endurance (Gollnick, 1984; Makrides et al, 1990) Trainings, lead to increased quality of endurance performance, and studies on concurrent strength and endurance training have showed better results than doing one method alone (Paavolainen et al, 1999). These theories controlling endurance performance to achieve maximal results in competitions gave anchor to trainers as they design their conditioning programs for athletes. This research aimed to examine the effects of using weighted vests in endurance training of high school boys by comparing the pre- and post-test differences between groups using other training methods. The study focused on giving options in improving endurance performance of adolescent boys with resistance training outside the weight training facility.

Material & methods

Participants- Twenty-six (N=26) qualified participants were randomly assigned to three experimental groups: Endurance group (E=7), Endurance and Strength training group (EST=8) and Endurance with weighted vest group (EWV=11). They were male high school club members with mean age (years) of 14.5±0.81. All participants are beginners in endurance running. Members of competing teams who gained more than a year of training experience, as well as participants who were diagnosed with heart-related or cardiovascular disorders by a physician were not included of the study.

Instrumentations

*Physical Activity Readiness Questionnaire (PARQ)***.** The questionnaire (2002 PARQ and You) was used in this study for the pre-participation screening of participants as part of the inclusion criteria of the study.

Ratings of Perceived Exertion Scale (RPE). Scale was used to assist in the monitoring of physical exertion. The scale was from 0 to 10 (10 being *Very very hard*) printed in a 3ft x 4ft tarpaulin, making it visible outdoors. Participants were familiarized with the use of the scale to maintain level of exertion throughout the intervention.

Omron® Body Fat Handheld Monitor (HBF-306). The handheld bioelectric impedance devices (Figure 1) were lightweight and user-friendly. Several information are needed to calculate percentage i.e. height (cm), age and weight (kg). It has been used in a study (Moulton, 2013), and shown to be an efficient tool in assessing change in body composition.

Figure 1. Omron® Body Fat Hand-held Monitor (HBF-306)

20-meter Multistage Test (20MST). A 20-meter bleep test was used to estimate pre- and post-test VO_2max results. Level attained by the participants was utilized to predict maximum oxygen uptake values, using the standards of 1987 Loughborough University. The progressive shuttle-run test was done in a covered gym inside the campus.

Nordic Track Vest. This training equipment is one of the many variants of weighted vest that is made by Nordic Track. It was used in training of the EWV group. The equipment (Figure 2) is adjustable to fit the participant's body. It has nine sand pockets placed to accommodate different loads of weight.There are two available straps securable by a Velcro. Sand bags were modified to accommodate 5%BW load to EWV group.

Casio Stopwatch HS-3. A handheld device used to record running time of subjects, in both pre- and post-test, with precision of 99.997685%; timing unit: 1/100 s (Espinoza-Fernandez et al, 2003).

Figure 2. Nordic Track Vest

Study Procedures

Pre-Experiment Routine. Subjects were taught with standardized dynamic stretching routines, used as warm-up in the course of the program. Running-specific drills were done by participants, focusing on the specific technique of running. Such drills were A-March, Ankling, A-Skips, Bounding, A-Runs, Fast-legs and short sprints. Familiarization of warm-up routine was done days prior to the pre-test day. Significant amount of rest was given between sets, enough to eliminate endurance-related adaptations.

Collection of data. Observed scores from the 3000-meter pre-test were arranged from lowest to highest, and were assigned to three equal groups in the beginning of the experiment (in Thomas, Nelson & Silverman, 2005) via systematic random assignment. After the experiment, a 3000-m run post-test was administered in three groups, and observations were analyzed. Summary of testing procedures is as follows:

(i) Percent Body Fat- Anthropometric measurements such as height (cm) and weight (kg) were administered by the researcher. Measurements were encoded in the BIA device as part of the required data for calculation. The collection of data was done before and after the training program.

(ii) VO_2max- Participants were subjected to a 20-meter multistage test (20MST) to gather pre- and post-VO_2max. They had a 10-minute dynamic warm-up before the facilitation of the test. Participants were instructed to run in between bleeps. Performance of each subject was recorded after failing to catch the bleep for three consecutive times. Performed level and number of shuttles were recorded, utilized predicted maximum oxygen uptake values using the standards of Loughborough University (1987), and immediately encoded in an Excel file. The progressive shuttle-run test was done in a covered gym inside the campus. No testing was done the following day.

(iii) 3000-meter Run- Runners began with the time trial in a mass start. The test simulated a 3000 meter race in an Olympic-sized track oval, recording result using a hand time. Each runner was timed throughout the completion of the distance. A lap official monitored runners, giving them feedback for current lap they are in. Participants were reinforced to run at a rating of perceived exertion (RPE) level of 8-10 as they cross every lap. Protocols and recorders were consistent from pre-test to post-test. Running time of participants were recorded in a piece of paper and immediately encoded in an Excel file. Run trials (both pre- and post-test) were done 48 hours after the 20 MST tests.

Three treatments were done in a period lasted for 8 weeks. A base training was applied to all groups in the first three weeks (Snyder, 2012). From week 4-6, groups went through first stage of their respective programs, which will all progress in the 7th and 8th week. The summary of training procedures is as follows:

(i) E Group- Participants were subjected to 2 sets of 2000 meter endurance running with a 3-minute rest between sets at an RPE of 7 to 10. As the intervention progressed, the rest interval was lessened to reinforce endurance developments among participants.

(ii) EST Group- Participants went through both 2 sets of 2000-meter endurance running at an RPE of 7 to 10, and weight training. Participants spent 30% of total training frequency in weight or resistance training (Mikkola et al, 2007). Strength training included lower extremity exercises namely Squats, Leg Press, Leg Extension, Leg Lunges and Heel Raises, and upper extremity exercises particularly Dumbbell Rows (Alternate), Dumbbell Front Raises and Dumbbell Bench Press, all at 60-70% of the predicted 1RM (in Brzycki, 1998; in Baechle, Earle &Wathen, 2000; in dos Remedios, 2007), with 10 repetitions done in 3 sets. Overload in resistance started on the 7th week ranging from 10-40% addition to the previous load.

(iii) EWV Group- Participants undertook 2 sets of 2000 meter running. Contrary to the E group, a vest with a load of 5%BWwas worn by EWV participants on the 2nd set of the exercise. Same amount of rest was applied to EWV; however, a 1-kg load was added on the 7th week.

Ethical Considerations. The researcher notified the school head stating his intention to conduct research and solicited for consent. Participants were oriented on the nature of the study, expectations, risks and discomforts they might encounter. They were assessed for participation using the PARQ and signed parental consent forms before proceeding with the research.

Statistical Analysis- Differences in running time, VO_2max and %BF within groups after interventions were analyzed using the Wilcoxon Signed-Rank Test while change (Δ) or intra-differences across three groups were analyzed using Mann Whitney U, Kruskal-Wallis H test and Friedman Test. Correlations between running time and other variables specifically VO_2max and %BF were analyzed using Spearman Rank-Order Correlation. Bar graphs were utilized for visual presentation of differences in pre- and post-test scores.

Results

Table 1 shows the level of heterogeneity of the subjects in terms of 4 variables; %BF, heart rate, height and weight. Sixty nine percent of the subjects measured to have a Normal %BF assessment based on Lohman's (1986) obesity assessment, 19.23% of them were Slightly High, and 11.53% were considered High. The mean %BF posed that in average, subjects were Normal based on standard.

Table 1.*Demographic Profile of Participants*

Variable	N	Mean	Std Dev	Variance	Range
% Body Fat	26	17.40	5.18	26.82	19.52
age (yrs)	26	14.50	0.81	0.66	3
height (cm)	26	167.54	8.81	77.66	31.5
weight (kg)	26	59.64	21.34	455.41	108
Heart Rate	26	81.69	9.20	84.62	33.0

(bpm)

Average height in relation to mean age of subjects was at 50th percentile based on the data collected by National Center for Health Statistics (2000). This shows that the statures of the participants in average are higher than the 50 percent of the population. Furthermore, average weight in relation to age using the same standards is below 75th percentile.

Figure 3 shows the average running times ($RT_{ave)}$ of three groups from pre- post-test. The scores from the pre to post test of all groups have a direction towards improvement after the implementation of different training methods. RT_{ave} of group E had a difference of 15.71secs, EST group RT_{ave} had a difference of 95secs, and EWV group RT_{ave} had a difference of 146.45secs. Upon validating for no significant differences between pre-test scores of each group, the EWV exhibited the biggest difference in the analysis of mean running time in contrary to what the E group has exhibited.

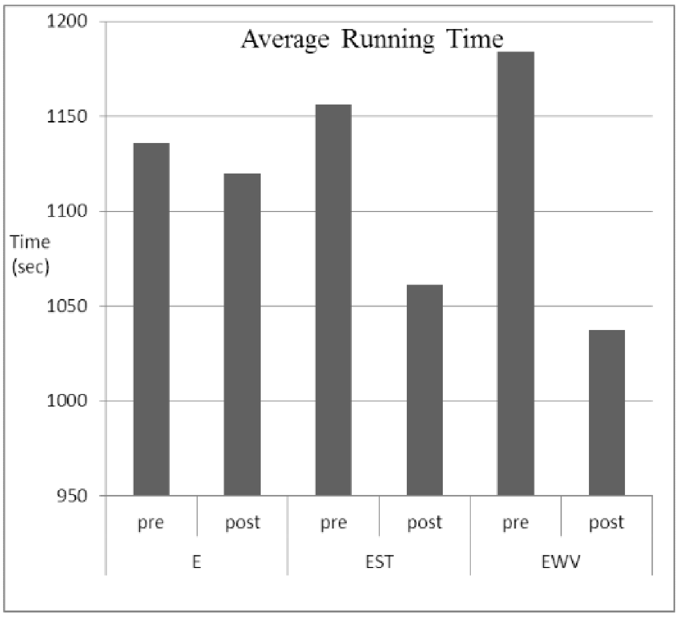

Figure 3. RT_{ave} of obtained in seconds.

Table 2 presents statistical scores comparing the pre- and post-tests applied to each group. Columns present the critical values based on the number of *n* and W value from the two observations. For the 3000-meter running time, E group obtained the highest W of 10, with 7 units away from the critical value. This is comparable to the W value obtain in the EST, having a smaller value of 8, and closer to the significance level of 5. Using the Wilcoxon Signed-Rank test, statistical score will express a level of significance if it is lower than the critical. The W score obtained in the EWV is 9, within the critical level, making the score significant at <0.025. The tool calculated a p value of 0.016, validating its low probability for error.

Table 2.*Comparing differences using the Wilcoxon Signed-rank Test*

Pre- and Post-test	3000m running time	VO2max	%BF
E	W= 10 Critical (p<0.05)= 3 Z= -0.68	W= *0 Critical (p<0.05)=2 Z= -2.20	W= 7 Critical (p<0.05)=2 Z= -0.73
EST	W= 8 Critical (p<0.05)= 5 Z= -1.40	W= *0 Critical (p<0.05)=3 Z= -2.37	W= 9 Critical (p<0.05)=5 Z= -1.26
EWV	W= *9 Critical (p<0.05)=13 Z= -2.13 P= 0.016	W= *4 Critical (p<0.05)=13 Z= -2.58 P=0.004	W= 15 Critical (p<0.05)=10 Z= -1.27

*significant

In all three groups, the significant increase is evident among participants' VO_2max through the 20MST. Critical level in EWV exhibits the greatest with 13, compared to 3 and 2 of EST and E respectively. However, looking at the z ratio, only the EST and EWV group are significant at 0.01, making the values consistent to 99% of other investigations.

In the last column presenting change in the aspect of %BF, it showed no significant difference in all three groups at 0.05. With $z_{critical}$ of 1.645, EST and EWV showed a stronger trend.

The researcher was able to assess VO_2max scores before and after the three training methods. Acquired average scores are presented in Figure 4 from collected scores of 26 subjects, ranging from 26.8-51.9 mL/kg/min in the pre-test and 26.8-50.8 mL/kg/min in the post-test. E group attained an increase in average VO_2max of 2.22mL/kg/min. EST group came up with an average increase 8.03mL/kg/min after 8 weeks. EWV group attained an increased average VO_2max of 6.24mL/kg/min. Among the 3 groups, EST group exhibits greater improvement in the analysis of average VO_2max, unlike its comparison with other groups in the average running time.

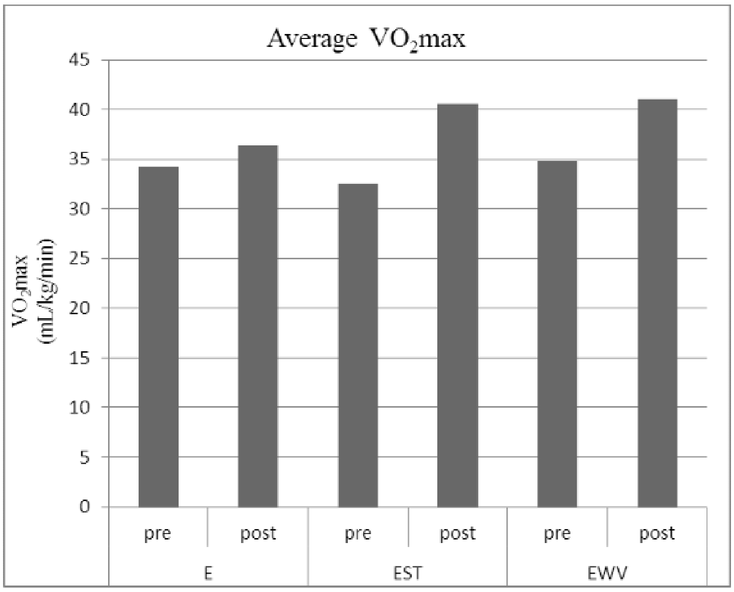

Figure 4. Averages of obtained VO_2max scores in mL/kg/min using the 20 MST.

Table 3 shows a Very Strong (r >.70) negative relationship between running time and VO_2max. After 8 weeks, it appears that the intervention strengthened its negative relationship further, from -0.768 to -0.879. This suggests that training, regardless of the method, increases an individual's VO_2max, and decreases running time.

For both observations (pre and post), a Moderate (-.39 < r < -.30) negative correlation between VO_2max and %BF of participants was found. Inclusion of a training program, regardless of the method, showed minimal influence in the relationship between the two variables.

Table 3.*Correlation between dependent variables using the Spearman Rank-Order*

	Running $Time_{pre}$	**Running $Time_{post}$**	**VO_2max_{pre}**	**VO_2max_{post}**	**$\%BF_{pre}$**	**$\%BF_{post}$**
Running $Time_{pre}$	-	-	r_s= -0.768 p=0.000005 t= -5.88	-	r_s= 0.33 p=0.09 t= 1.73	-
Running $Time_{post}$	-	-	-	r_s= -0.879 p<0.000001 t= -9.06	-	r_s= 0.19 p=0.36 t= 0.94
VO_2max_{pre}	-	-	-	-	r_s= -0.36 p=0.068 t= -1.91	-
VO_2max_{post}	-	-	-	-	-	r_s= -0.32 p=0.13 t= -1.59

Correlation between running time and %BF also showed a Moderate ($.30 < r < .39$) positive correlation. However, data shows that after the 8-week training, Negligible ($r = .19$) relationship was generated between running time and %BF. In general, data showed a Weak ($.20 < r <.29$) positive correlation between running time and %BF. This suggests that regardless of what method, training disassociate running speed from body composition.

With the interest of comparing improvements between groups, change (Δ) of scores from each subjects or the intra-differences were attained by getting the difference between their pre-test and post-test scores. Scores were statistically analyzed using the Kruskal-Wallis H and Friedman Test. Table 4 shows consistency between results of both statistical tools. It confirms that in terms of VO_2max, differences in change from post- to pre-test are significant between the 3 groups with p values at 0.05. Differences between 3 groups in terms of running time are found not significant, but shows stronger trend when compared to differences in %BF.

Intra-differences were compared using Mann Whitney U and values are presented in Table 5. It shows values consistent with scores presented in Table 2. In the 3000-meter running time, z ratios reveal that the EWV intervention is statistically superior in giving improvements in relation to E and EST with distant ratios of 1.36 and 0.95 respectively, while the z ratio between ΔE and ΔEST is 0.17.

Analyzing the improvements in VO_2max, Table 5 also shows that comparing the 3 interventions, those with strength training are significantly different at 0.05 from that without strength training. Comparing to E, EST and EWV improvements show z ratios of 2.43 and 2.03 respectively.

Comparing %BF improvements across groups, Table 5 shows that improvements in EST group are statistically different when mixed with the other groups. It has a z ratio of -0.69 when compared to E, and 0.49 when compared to EWV. Improvement in the body composition is consistent to the idea discussed by Anderson (2011) about protein synthesis in weight training.

Table 4. *Comparing the intra-differences or change (Δ) within groups*

Parameter	**Kruskal-Wallis H Test**	**Friedman Test**
Running Time	H= 2.13 P= 0.343	csq_r= 2.04 p= 0.36
VO_2max	H=7.09* P=0.029	csq_r= 6.13* p= 0.046
%BF	H= 0.493 P= 0.781	csq_r= 0.29 p= 0.865

*significant

Table 5. *Statistical difference between intra-differences of groups using the Mann Whitney U*

	ΔE_t	**ΔE_{VO2}**	**$\Delta E_{\%BF}$**	**ΔEST_t**	**ΔEST_{VO2}**	**$\Delta EST_{\%BF}$**
ΔEWV_t	U= 23 $p<0.05$= 16 Z= 1.3585 P= 0.17	-	-	U= 32 $p<0.05$= 19 Z= 0.9496 P= 0.34	-	-
ΔEWV_{VO2}	-	U= 15.5 $p<0.05$= 16 Z= 2.03* P= 0.041	-	-	U= 35 $p<0.05$= 19 Z= -0.701 P= 0.483	-
$\Delta EWV_{\%BF}$	-	-	U= 38 $p<0.05$= 16 Z= 0 P= 1	-	-	U= 37.5 $p<0.05$= 19 Z= 0.495 P= 0.617
ΔEST_t	U= 26 $p<0.05$= 10 Z= 0.1736 P= 0.865	-	-	-	-	-
ΔEST_{VO2}	-	U= 6.5 $p<0.05$= 10 Z= 2.43* P= 0.01	-	-	-	-
$\Delta EST_{\%BF}$	-	-	U= 21.5 $p<0.05$= 10 Z= -0.694	-	-	-

P= 0.49

*significant at 0.05

Dicussion

The results of the study supported the findings of Holloszy (1967) and Davies (1981) on resistance training and endurance-related performance. Their work greatly influenced the design of the EWV group with weight-bearing running is done at the latter set (Anderson, 2011). This as well is consistent with the EST group where strength training is done during the last session of the week. Improvements in both EWV and EST groups are consistent to previous studies done with the integration of strength training in developing endurance and running speed using male non-adolescent subjects (Taipale, 2013; Sawyer et al, 2014).

Increased intensity endurance training show positive trend in running performance, giving greater improvements in oxidative capacity as what the correlation between running speed and VO_2max has shown. This increase capacity to process oxygen to sustain performance has been mentioned also by Davies (1981), sustained by the theory of increased mitochondrial enzyme activity (Kong et al, 2010; Aquilano et al, 2010; Austin &St.Pierre, 2012) via evident protein signals (Gollnick, 1984; Popov et al, 2014; Little et al, 2010; Wackerhage et al, 2011). This intensity brought by weight training reinforced the role of mitochondria with it enhanced oxidative activity as mentioned.

Percent body fat showed no significant change in three interventions. Relationship of %BF scores with running time and VO_2max also showed weak trend and association between performance-efficient individuals and the profile of %BF. This opens discussions for further investigation on the effect of endurance training to %BF profile, in relation to the study of Coggan (2000) and Tolfrey (2000) about making use of fat as energy.

EST group showed results similar to Kelly (2008) where integrated strength training with aerobic running gave better 3000-meter running time rather than doing unmoderated aerobic running alone. However, results shown no significant change in running time after the intervention, considering the factors stated by Smrkolj and Skof (2013) in their study about no induced change in muscle fiber composition after weight training. Results of the group also exhibits traces of similarities in Taipale (2013) in the investigation of different training methods, validating the claim that resistance training that are only explosive in nature can affect maximal running speed. This is in contrast to the maximal strength training nature of the EST as presented by Taipale (2013).

Another aspect need to discuss about the resulted running time of the EST group is the speed trait of how training is carried out. It is in the nature of the EST training to be done at an average speed, given that the exercise load is at approximately 60-70% of their 1RM. EWV group possessed a favorable result because it matches the face validity of the 3000-meter run test. Wilson (2012) presented this value of high velocity training in developing fast fibers leading to improved speed. EWV participants had allowed essential segments to go through resistance training on specific speed.

Among the different factors that affected the outcome, specificity of the given intervention program will not be disregarded in the discussion and analysis of results. It is seen how the EST and EWV group has been prominent in the analysis of RT_{ave} and average VO_2max. The nature of test as a factor has worked a lot in the presented outcome difference. Weighted vest use for training has allowed participants to cultivate the specific facets of running in detail during the training period. Resistance from the vest gave hypergravity and ground reaction forces on the running system (lower extremity), particularly in the toe-off phase of the cycle (Young-Hui &Kram, 2007). It allowed this resistance to act with the actual speed of movement, relative timing and specific coordination of the other joints involved in the lower extremity (Nemtsev & Chechin, 2010). This force acting on the system is becoming more functional in acceleration segments of the run.

Training of the EWV group involved specific conditions of segments in the running extremities. These specific components are exclusive to straight lanes and to the degree of turn in the curve lanes. One of the experiences in running the oval in particular is the stride difference of the left and right leg (Young-Hui & Kram, 2007) at the 100-meter curve. This implicates a different armswing pattern in relation to the plane of armswing movement while running the straight track. With its applicability, the whole process in this research has also shown how the weighted vest can be applied while running in a more expansive area, addressing as well the conditions applied in the method. The functionality greatly contributed especially for cases related to specific angle of the 100-meter curve, and probably specific surface of the running track.

Conclusions

After the 8-week intervention, the results of the investigation showed a greater change and significant difference in the 3000-meter running time of the EWV group at $p<0.02$. Despite no exhibited significant change in running time among the EST and E group, all participants were directed towards improvement in running time with the 3 training methods.

Results within all three groups exhibited significant differences in VO_2max at $p<0.05$, and was evident at $p\leq0.03$ when analyzed using the Kruskal-Wallis H and Friedman Tests. Changes in VO_2max shown the positive influence of strength training when difference between E and EST ($p=0.01$), and E and EWV ($p\leq0.05$) are found to be significant. No significant difference in improvement was found when EWV and EST are compared. While no significant change shown in %BF after the intervention, z scores suggests that changes are higher among groups with strength training methods.

Conflicts of interest - None to declare.

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