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Z-score results on long distance running comparing on university student and Athletes

Introduction

The participant in this study is a long distant runner and is 21 years old. Endurance athletes or long-distance runners need a combination of physiological adaptations to compete with others, as it requires a significant amount of physical exertion this is due to it sustained efforts for extended periods (Yao, 2023). It endures an array of different components in the body, cardiovascular, muscular, metabolic, adaptations to excel (Thompson These key components enhance physiological adaptations that can help the runner transition from amateur to elite in sports (Bachon, 2024).

Increased heart efficiency is needed for optimal oxygen delivery to the working muscle, thus meaning that the heart can pump blood with minimal effort (Kocic, 2024). This is crucial for endurance runners as it is needed for intense sustained activity, this will maintain greater cardiac output and the heart can reach higher heart rates and be maintained for longer periods without becoming fatigued thus leading to improved performance (Bachon, 2024). This means that stroke volume increases and the heart does not need to beat as often to maintain the same output (Bachon, 2024). With increased stroke volume the heart will strengthen in particular the left ventricle as it allows to pump more blood per minute (Maria, 2024). The demand for these functions all come from increased plasma volume which enhances stoke volume and cardiac output (Kocic, 2024).

This in turn will improve VO2 max, understanding VO2 max is critical for athletes as it determines the athlete's aerobic fitness and endurance potential (Stoa, 2020). This is done by measuring the amount of maximal oxygen uptake utilised by a person during intense exercise. VO2 is crucial to generate locomotive efforts for long distances runners (Hausswirth, 2018). VO2 max tests can monitor heart, lungs, and muscle efficacy (Srivastava, 2024). Stoa, (2020) found in research that female long distance runners results for VO2 max on the treadmill were 59.1 ± 7.5 mL/Kg/min this showed significantly ($p < 0.001$) higher VO2 max levels in female runners. This result will be compared to the chosen participant VO2 max result to see if the participant is at a similar athletic level (Srivastava, 2024). Understanding VO2 max can help create personalised training plans and training zones which can be put in place. Greater understanding can enhance performance, recovery, and avoid overtraining (Boullosa, 2020; Seiler, 2010). To establish specific training zones there needs to be an understanding of maximal heart rate, each zone is specific to different physiological adaptations there are 1 to 5 zones and endurance runners will mainly focus on zones 1 low lactate metabolic phase and

zone 2 the lactate accommodation phase, this is a lower intensity to enhance stronger aerobic fitness (Boullosa, 2020; Seiler, 2010).

For endurance sports such as long-distance running type 1 or slow-twitch muscle fibres would be efficient for this particular sport (Plotkin, 2021). Type 1 fibres are great at using oxygen and glucose to produce as energy (ATP) (Dong, 2023). Type 1 fibres contract slower than type 2 fibres therefore the slow and steady contraction makes it ideal for longer durations in exercise as it relies on using fat and glycogen as fuel rather than lactic acid which type 2 fibres produce more of than type 1 (Dong, 2023). Slow twitch fibres can contain a large number of mitochondria which can prevent lactic acid build up thus using lactate as a fuel source by the mitochondria this will prevent muscle soreness and prolong activity (Dong, 2023).

Muscle fibre types are one of the key factors to running economy (Smoliga, 2016). A higher running economy means that the body can run faster with minimal effort (Smoliga, 2016). efficient running economy leads to better utilization of oxygen (Smoliga, 2016). Individuals that have a more efficient running economy have a lower metabolic demand at submaximal intensities, thus making them perfect candidates in long distance running (Smoliga, 2016). Running economy is measured VO₂ metabolic chart (Smoliga, 2016)

A high lactic acid threshold is a curtail for long distance runners as it is physiological marker to see how the muscle cells and red blood cell's ability to utilize lactate (Subbarayalu, 2024). A higher lactic threshold maintains a higher VO₂ max, thus meaning more efficient endurance performance (Subbarayalu, 2024). By understanding an individual's blood lactate concentration then specific training loads can be implemented to the athlete to give optimal training programs (Casado, 2023).

To get optimal muscle strength function is crucial in sports such as long distance running it is important as it maintains flexibility and reduces injury (Widodo, 2020). It is highly important to implement exercises to increase muscle efficiency and strength by implementing isometric exercises in training will help tendon quality, strength, power, muscle fatigue delay, voluntary activation, and range of motion these interventions are used to treat injured individuals and athletes. This specific exercise is aided to protect from hamstring injury which is high at risk from long distance running (Widodo, 2020).

Body composition plays an important role in many sports this includes long-distances running (Cullen, 2020). Body composition can influence sport performance studies found that a high amount of body fat can affect power to weight ratio (Cullen, 2020). This will also affect acceleration and increase energy expenditure thus, effecting time and performance which is crucial for long distance runners (Cullen, 2020). However, a lower fat mass can have negative effects to performance and can come with complications (Cullen, 2020). An evenly distribution to fat mass and muscle mass is extremely important in this particular sport (Cullen, 2020).

Method

An array of tests were conducted on a group of university student's both male and female aged 19- 24 years. The chosen tests on the group for the findings for this case study report were VO2max, agility, and hand grip dynamometer. All tests were performed at the University of Wales Trinity Saint David in the university lab, where results were analysed using Microsoft Excel. The average scores for the group were calculated. In order to evaluate the performance in comparison to the group mean the z-score for one participant, a 20year old female, was calculated. The z-score calculation was used to measure the standard deviation to determine how many standard deviations the z data point was from the group mean. Positive z-scores indicate values above the mean, while negative z-scores indicate values below the mean.

This individual is a competitive long-distance runner, and the specific test were chosen to compare the individual to the other students and the research that has been collected. The chosen participant body composition was recoded on the (body composition analyser DC-360).

VO2 max test was conducted on the Wattbike (Wattbike, Nottingham, UK). on all students all bikes were the correct seat hight for each individual and heart rate was recorded (Polar Electro, Warwick, UK). The intensity of the bike gradually increased till the point of maximal effort, once this was reached each participant was given a noise-clip to apply to the noise and given a mouthpiece attached to a valve where expired air was collected to measure oxygen intake and the output of carbon dioxide using the dry gas meter (Harvard, Massachusetts, USA). This was collected during the last 60 seconds of where each participant reached their submaximal effort, after the measurements were taken, the participants were asked to do a cool down session before finishing the test. Hand grip dynamometer (Niigata City, 956-0113 Japan) was performed on all students, for each individual the length on the handle was adjusted to what felt comfortable in the hand. Participants held the hand grip dynamometer in the right hand and was asked for the palm to be facing up and elbow approximately 90 degrees. When the participant was ready, they squeezed the dynamometer with maximal effort for 3 seconds. The force value on the dynamometer was recorded in Kg, the participants was asked to repeat the test two more times with a two-minute brake for each attempt, then repeated on the left hand in the same procedure the results were calculated and was recorded on excel. The reason for this test was to measure overall body strength and isometric strength.

Results

The mean age of both the male and female students was 20.72 ± 1.67 . the mean and standard deviation of VO2 max on the Wattbike was 37.65 ± 11.44 ml/Kg/min. The mean and standard deviation of agility was ± 1 SD on the bell curve chart, the group fell into the average range. For grip strength the groups mean, and standard deviation was ± 1 SD this shows an average range.

For the chosen female a z-score was calculated to indicate what category level of fitness she would fall under at the age of 20 years and a VO2 max of 59 ml/kg/min. Her z-score calculations were 1.87. For agility the z-score was 2.14. Grip strength results show in the z-score -1.67 .

Weight was 54.1Kg, fat % 12.9%, fat mass 7.0%, muscle mass 44.7% bone mass 2.4Kg, BMR 5954 KJ, and BMI 18.5.

Table 1. (Students results, Chosen Female is on the 7th row).

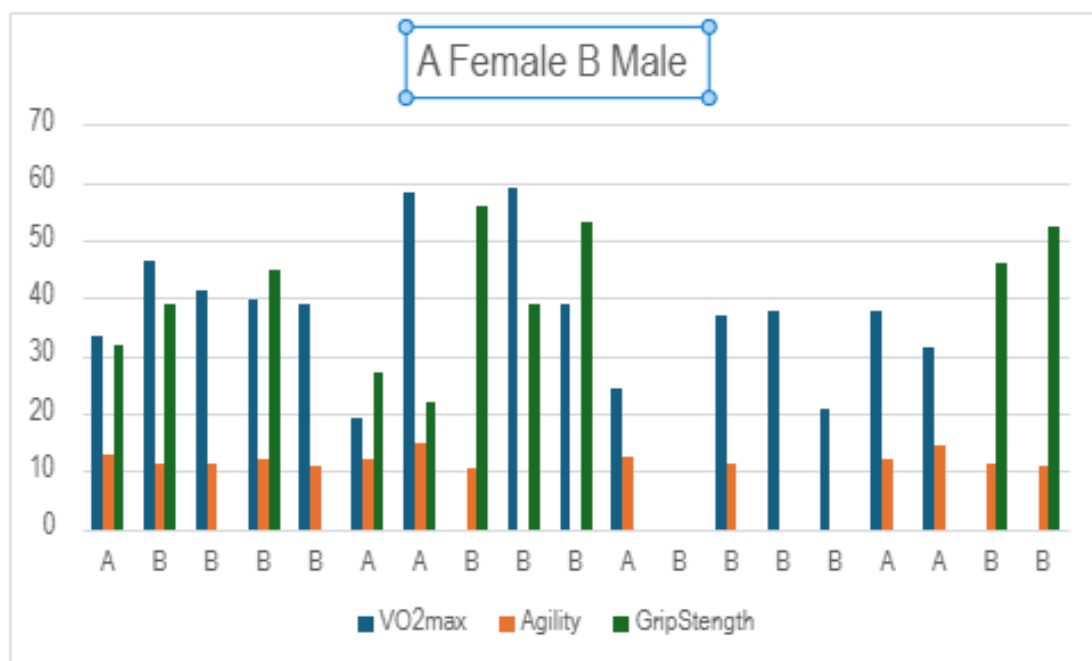


Table 2. (VO2max group test results).

	N	Minimum	Maximum	Mean	Std. deviation	Z-score of female
VO2max	15	19.4	59.2	37.6533	11.43896	1.87
Valid N	15					

Table 3. (Agility group test results)

	N	Minimum	maximum	Mean	Std. deviation	Z-score of female
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Agility	14	10.69	14.89	12.0993	1.30539	2.14
Valid N	14					

Table 4. (*Hand grip goniometer*).

	N	Minimum	Maximum	Mean	Std. deviation	Z-Score of female
Grip strength	10	22	55.80	41.1500	11.43341	-1.67
Valid N	10					

Table 5. (*VO2max results of Athletes, Subject, and Students*).

Athlete Distance runners	Chosen Subject	Students result
59.1 ± 7.5 mL/Kg/min	59 ml/kg/min	37.65 ±11.44 mL/Kg/min

Discussion and conclusion

The results showed that the individual whose z scores of 1.87 was well above the group average for VO2 max. The participant has a strong aerobic capacity and is at elite level. The z-score results represent where the standard deviation falls and, in this case, it is ± 2 standard deviations. This individual is well above the mean indicating a significantly higher VO2 max than the majority of the students. This also places her in the superior percentile making her an excellent candidate for professional sport for long distance running (Srivastava, 2024). This indicates that the individual's cardiovascular system is strong and efficient (Bachon, 2024). Comparing to research she falls into the category of athlete level (Stoa, 2020). Her aerobic capacity is high, meaning that she can sustain extreme physical exertion (Stoa, 2020).

Results from VO2 max test also suggests that the participant's running economy is highly efficient this means her muscle fibres are more likely type 1 (Dong, 2023; Subbarayalu, 2024; Stoa, 2020). This indicates she has a high lactic threshold meaning she can sustain higher intensities for longer durations (Subbarayalu, 2024; Dong, 2023).

Agility score shows that the participant z-score 2.14, results indicate that she is slower than average, If the participant trains more on her agility, then she can increase her running efficiency and have a more stable form (Teng, 2023). By implementing this into her training then the risk of injury is lowered as it will improve balance and less chance in injury in ankles, knees and hips. All very important for long distance running (Teng, 2023).

Body composition plays a vital role in the sport the participant engages in (Cullen, 2020). Results from body composition indicates that the female body type is athletic (Cullen, 2020). The participant has very little body fat and is efficiency is good (Cullen, 2020).

However, BMI was 18.5 this does put the participant in the underweight category (Hernández, 2021). Being underweight can cause complications such as eating disorders this is psychological and can be dangerous as the competitiveness of the sport this can present unhealthy behaviours and compulsive exercise (Cullen, 2020). It is highly important to ensure nutritional needs are met especially if one is engaging in such a high demanding sport as it could have potential health risks (Cullen, 2020).

Grip strength had also shown a below average with a z-score -1.67 grip strength often reflects on overall muscle strength these results can become a great concern in the type of sport the participant engages in the reason for this is she is at greater risk of injury mainly concerning the hamstrings and tendons (Stavridis, 2025). A suggestion to the participant is to do more isometric exercises this will strengthen the hamstrings and tendons in the legs making the risk lower to sport injury's and improves acceleration (Stavridis, 2025). However, with results of VO₂max this would suggest that the participant has type 1 muscle fibres and a high running economy this means she can maintain a faster speed at a lower oxygen consumption, making her an excellent component to long distance running (Smoliga, 2016). The participant will have a high lactic threshold thus, her ability to run faster and longer distances before lactate build up affects performance (Subbarayalu, 2024).

For the participant to improve performance there are different training intervals that can be included (Llanos-Lagos, 2024). Strength training with higher loads of a one repetition max this will improve strength but will not gain unnecessary weight to the participant which is crucial for long distance runners, Plyometric training this involves explosive movements such as jump squats, box jumps this will increase power and speed, these particular training methods will improve running economy (Llanos-Lagos, 2024).

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