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# Associations of whole body reaction time with anaerobic power performance among Saudi athletes in different sports

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ABSTRACT

This study aims to analyze the associations between whole-body reaction-movement time (RT) and anaerobic power performance among Saudi athletes participating in different sports. Fifty athletes (age 18-26 years) of four different sport groups representing sprinters (SP, n=12), fencers (FN, n=13), table tennis player (TT, n=12) long-distance runner (LD, n=13), and one non-athlete group (NA, n=8) participated in the study. All groups performed Wingate Anaerobic Test (WAnT), and the vertical jump (VJ) test. RT was recorded using a sound (RT-S), light (RT-L), and a choice of light (RT-C). There were no significant differences in reaction-movement time between LD, SP, FN, TT, or NA groups. However, tests between subjects showed significant differences relative to sport type in muscular power (p=0.011), absolute maximal anaerobic power (p=0.008), absolute average anaerobic power in 30 seconds (p=0.001), average anaerobic power relative to body weight (p=0.007), and in fatigue index (p=0.028). Fencers recorded the highest values in absolute anaerobic power, absolute average power in 30 seconds, and average anaerobic power relative to body mass. Sprinters showed the highest decrement in anaerobic power during the 30-second test (18.7±6.0 watts/sec). Partial correlation coefficients (r) of selected anthropometric variables with reaction time and anaerobic power were calculated. This study showed that there were no significant changes in reaction-movement time between LD, SP, FN, TT, or NA groups. However, tests between subjects showed significant differences relative to sport type in muscular power, absolute maximal anaerobic power, absolute average anaerobic power in 30 seconds, average anaerobic power relative to body weight, and fatigue index.



## 1. Introduction

Physical testing of team athletes is a necessary element in the assessment of coaching programs and the evaluation of players' progress throughout the event (Delextrat and Cohen, 2008). Positive performance in sports is affected by several psychological and physical features such as coping with stress, strategic thinking and strength, and endurance. After a high-intensity effort, mental and physical fatigue may appear, and both may affect performance including the capability to react rapidly. This ability is possibly very essential for contest sports athletes, where slower than required reactions reduce the possibility to reply effectively and succeed in a sport (Pavelka et al., 2020). To attain the best achievement during sports seasons, the trainers and players must know about the key elements which have impacts on general athletic performances (Taheri and Arabameri, 2012). Physical fitness can be measured through the five most important factors including muscular endurance, muscular strength, cardiorespiratory endurance, body composition, and flexibility.

All team athletes who are taking part in sports should have some benefits in their motor skills. This expertise is to be developed by coaching. It is a fact that endurance, agility, flexibility, strength, and balance of which are the elements used successively in aerobics and anaerobic systems which affect the performance of both individual sports and team sports (Tamer, 2000). For a successful sports event, it is very important for every athlete to show great performance regarding physical and motor skills.

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Anaerobic power and reaction time are two main aspects influencing the performance of various sports (Koç et al., 2006).

Reaction time can be described as the time that passes between receiving an unexpected and an immediate stimulus and reaction given to it. Reaction time can be assessed by using a light stimulus, sound stimulus, or a choice reaction time using a light stimulus. It is a physiological ability closely associated with human activity. It shows the level of neuro-muscular coordination in which the body via different mechanical, physical, and chemical routes interprets auditory or visual stimuli which travel through different sources and reach the brain as sensory stimuli (Shelton and Kumar, 2010).

It has been revealed that the reaction time to sound is faster than the reaction time to light (Shelton and Kumar, 2010; Pain and Hibbs, 2007). In contrast, other studies found that reaction time to light is faster than reaction time to sound during or after exercise (Yagi et al., 1999; Verleger, 1997). Reaction time depends on a number of factors the influx of the stimulus at the sensory organ, the transformation of the stimulus by the sensory organ for processing of neural transmissions through neural signals, soft tissue compliance, muscular activation, and the selection of an exterior assessment scales (Pain and Hibbs, 2007). Quicker reaction times are important for the best performance of athletes. Reaction times are usually used to assess neuromuscular-physiological reactions in sports. A previous study by Kemp (1973) showed that a visual stimulus takes 20-40 milliseconds while an auditory stimulus takes only 8-10 milliseconds to reach the brain. Pain and Hibbs (2007) have also reported the auditory reaction time for runners was around 85 milliseconds. This indicates that the faster the stimulus reaches the brain, the faster the signal is processed and the necessary responses are sent for the necessary motor reaction. Therefore, the auditory reaction time is faster than the visual reaction time. Ando et al. (2002) described that reaction times decreased with frequent training. Thus reaction times to a particular stimulus can be made faster with repeated practice and with sufficient rest in between stimuli. Atan and Akyol (2014) have compared the reaction time scores between the athletes involved in various sports. Football players had the fastest reaction time values however, they have lower auditory reaction time values than judokas players. Furthermore, simple right reaction time was found higher in judokas than in football and field track players. However, non-athletes reaction times were found higher than most of the athletes. Özmerdivenli et al. (2004) assessed the right and left-hand reaction time parameters of athletes in response to sound and light stimuli. Chandra et al. (2010) have discussed the effects of training and heat load over simple reaction time in college students and concluded that there is a decrease in visual and audial reaction time after the exercise.

Numerous tests including the WAnT (Taheri and Arabameri, 2012; Chromiak et al., 2004; Jordan et al., 2004), vertical jump test, standing long jump test, and Bosco continuous jumps (Taheri and Arabameri, 2012; Sands et al., 2004) have been used to evaluate an athlete's anaerobic capacity, peak power (a measure of muscular strength and speed) or both. Wingate Anaerobic Test (WAnT) (Taheri and Arabameri, 2012; Chromiak et al, 2004; Jordan et al., 2004) has been used to measure an anaerobic activity defined as energy expenditure that uses anaerobic metabolism (without the use of oxygen) by utilizing an exhaustive effort that lasts less than 90 seconds (Wilmore and Costill, 2004). There are two main energy sources involved during the WAnT. i) The adenosine triphosphate-phosphocreatine (ATP-PCr) system, which lasts for 3 to 15 seconds during maximum effort ii) is anaerobic glycolysis, which can be sustained for the remainder of the all-out effort (Wilmore and Costill, 2004). Thus, the WAnT measures the muscles' ability to work using both the glycolytic and ATP-PCr systems. Many sports including gymnastics, baseball, football, soccer, sprinting, and lacrosse, use anaerobic metabolism widely during competition. Finally, the change in power output from highest to lowest measurements makes the WAnT an important test for trainers, athletes, and researchers.

Up until now, anaerobic power testing (Wingate Anaerobic Test) research on a large population has not been conducted on Saudi elite athletes in different sports and there has been no ranking system established for trainers to understand test results. We formulated a hypothesis that reaction time might change after fatigue in different sports athletes and there would be a significant difference in light, sound, and choice reaction time after stimuli in Saudi athletes of different sports disciplines and non-athletes. Thus, the present study aimed to explore the associations of whole-body reaction-movement time with anaerobic power performance among Saudi elite athletes in different sports on anaerobic performance variables such as mean power and peak power acquired from the 30-second WAnT and choice reaction time. Also examined the correlation between, light, sound, and choice reaction time of variable parameters in different sports disciplines.

## 2. Methodology

### 2.1. Participants

Five groups of participants (18 to 26 years of age) were included in the present study. They represent various athletes in four types of sports (n=50) and a reference group of non-athletes (n=08). The athletes included long-distance runners (n=13), sprinters (n=12), fencers (n=13), and table tennis players (n=12). The athletes were recruited from national and subnational Saudi teams, through the Saudi Sports Federations. The reference group of non-athletes was recruited from university students. The research proposal was approved by the Institutional Review Board of King Saud University. The written informed consent was signed by all participants.

### 2.2. Anthropometric measurements

The body weight of all participants without shoes and with minimal clothing to the nearest 0.1kg was measured using Seca digital scale (model 770, Seca, Germany). Standing height was measured barefooted to the nearest 0.1cm using a calibrated measuring rod (Seca height measuring rod, Germany). Body mass index (BMI) was calculated as the body weight in kg over the square roots of height in meters. Body fat percent was then calculated by a prediction equation specific to youth. In addition, triceps, subscapular, and calf skinfold thicknesses were measured on the right side of the body by a trained researcher using the Harpenden skinfold caliper.

### 2.3. Reaction time testing

Reaction time testing included whole-body reaction-movement time with simple reaction time tests using light and sound stimuli as well as choice reaction time using light stimulus. Reaction time testing was preceded with a 5 min warm-up on the cycle ergometer with a brief (3 seconds) all-out sprint at the end of the warm-up period, followed by a period of rest. For testing reaction time, we used whole-body reaction measuring equipment from Takei Scientific Instrument Company, Japan. The participant was introduced to the testing with familiarity trials followed by three attempts and the shortest time was recorded. The reaction time instrument produces either acoustic or optical signals. When a participant is given such a signal, he is required to react to the signal by jumping off a reaction mat corresponding to the stimulus. The results of reaction time are recorded in a millisecond. For the three types of reaction time testing, we used a countermeasure protocol, so to avoid any learning effects on a particular test.

### 2.4. Anaerobic power testing/WAnT

Anaerobic power measurements were obtained using WAnT (Taheri and Arabameri, 2012; Chromiak et al., 2004; Jordan et al., 2004) with a friction-loaded cycle ergometer (Monark, Sweden), which was interfaced with a microcomputer. The resistance was set at 75gm/kg of body weight. The test was preceded with a 5 min warm-up on the cycle ergometer with a brief (3 seconds) all-out sprint at the end of the warm-up period, followed by a period of rest. The test was started after the participant reached a pedal rate of 100rpm, after which the resistance was then applied. Absolute as well as relative to body weight peak anaerobic power and average anaerobic power for 30 seconds were reported. Also, total work during the whole 30-second test as well as fatigue index was reported.

### 2.5. Vertical jump test

The Vertical Jump test (McKeag, 2003) is designed to measure an athlete's lower body strength. A vertical jump test was performed by using a wall-mounted movable jump and reaching the board. It was carried out in a standing position with both feet together before jumping as high as possible. All participants attempted 3 jumps with at least a 30-second interval and the best result was recorded. This test has very good test-retest reliability (Markovic et al., 2004).

### 2.6. Statistical analysis

Statistical analyses were performed using the Statistical Package for the Social Science (SPSS) program, version 22 (IBM, Chicago, IL). Descriptive statistics were obtained for all variables and reported as means and standard deviations or percentages. Differences between the participating groups in selected anthropometric measurements were tested using two-way ANOVA tests with multiple comparisons using the Bonferroni test. In addition, multivariable analyses (MANCOVA) were used to test differences in selected reaction time and anaerobic power variables stratified by the participating groups while controlling for the effect of age. Partial correlation coefficient tests were used to test the relationships among the study's variables while adjusting for age. The alpha level of significance was set at 0.05 or less.

## 3. Results

Table 1 describes the anthropometric characteristics of the participants relative to the type of sports. The fencers were the youngest of all groups. Training years averaged from 3.4 years for the sprinter to 6.1 years for the fencers. Also, the fencers were the heaviest and the tallest of all groups and possessed the largest lean body mass. BMI and fat percents were the lowest among long-distance runners (19.7±1.3 and 11.2±2.7%, respectively) and the highest among table tennis players (26.6±7.9 and 17.1±5.8%, respectively).

Multivariable analysis of reaction time and anaerobic power indices, stratified by sport type while controlling for age, are summarized in Table 2. Results show that there were no significant differences in reaction-movement time between long-distance runners, sprinters, fencers, table tennis players, or untrained university students.

Roy's Largest Root indicated a significant p-value for the main effects of sport (0.021) and an observed power of 0.941, The effect of age was also significant ($p=0.016$) with an observed power of 0.949. However, tests between subjects showed significant differences relative to sport type in muscular power ($p=0.011$), absolute maximal anaerobic power ($p=0.008$), absolute average anaerobic power in 30 seconds ($p=0.001$), average anaerobic power relative to body weight (p=0.007), and in fatigue index (p=0.028). Fencers recorded the highest values in absolute anaerobic power, absolute average power in 30 seconds, and average anaerobic power relative to body mass. Sprinters showed the highest decrement in anaerobic power during the 30-second test (18.7±6.0 watts/sec).

**Table 1:** Anthropometric characteristics of the participants (n=58)

| Variable | Non-athletes (n=08) | Athletes (n=50) | | | | *p*-value * |
|---|---|---|---|---|---|---|
| | | Long distance runners | Sprinters | Fencers | Table tennis | |
| Numbers | 8 | 13 | 12 | 13 | 12 | - |
| Age [1] | 21.6 ± 2.0 | 21.2 ± 2.5 | 21.7 ± 1.6 | 19.0 ± 1.0 | 21.4 ± 2.5 | 0.007 |
| Training years | 0.0 | 4.2 ± 1.7 | 3.4 ± 2.2 | 6.1 ± 2.3 | 5.9 ± 4.5 | 0.065 |
| Body weight (kg) [2] | 55.2 ± 8.9 | 55.3 ± 5.6 | 60.1 ± 8.1 | 65.5 ± 10.0 | 62.4 ± 10.1 | 0.023 |
| Height (cm) [3] | 163.5 ± 8.2 | 167.4 ± 6.3 | 169.0 ± 6.2 | 172.7 ± 6.9 | 168.7 ± 4.6 | 0.040 |
| Body mass index (kg/m$^2$) | 20.5 ± 2.1 | 19.7 ± 1.3 | 21.0 ± 2.2 | 21.8 ± 1.8 | 26.6 ± 7.9 | 0.095 |
| Body surface area (m$^2$) [4] | 1.59 ± 0.16 | 1.62 ± 0.11 | 1.69 ± 0.13 | 1.78 ± 0.17 | 1.71 ± 0.13 | 0.019 |
| Triceps skinfolds (mm) | 8.2 ± 2.8 | 5.8 ± 1.5 | 6.3 ± 3.1 | 7.1 ± 1.9 | 8.8 ± 3.5 | 0.040 |
| Subscapular skinfolds (mm) [5] | 10.9 ± 4.0 | 7.4 ± 1.5 | 8.2 ± 2.3 | 8.6 ± 2.1 | 11.0 ± 3.7 | 0.007 |
| Calf skinfolds (mm) | 7.5 ± 2.1 | 5.7 ± 1.5 | 6.1 ± 2.8 | 7.3 ± 2.3 | 8.2 ± 2.1 | 0.048 |
| Sum of skinfolds (mm)[6] | 19.1 ± 6.5 | 13.2 ± 2.6 | 14.5 ± 4.9 | 15.7 ± 3.5 | 19.8 ± 6.9 | 0.006 |
| Body fat percent (%) [7] | 16.6 ± 5.7 | 11.2 ± 2.7 | 12.4 ± 4.5 | 13.7 ± 3.4 | 17.1 ± 5.8 | 0.008 |
| Lean body mass (%) [8] | 45.9 ± 7.3 | 49.1 ± 4.8 | 52.5 ± 6.1 | 56.3 ± 6.7 | 51.3 ± 6.3 | 0.005 |

* Data are means ± standard deviations. Two-way ANOVA tests. Multiple comparison test using Bonferroni test: 1 = fencers are different from non-athletes (p = 0.047) and from long-distance runners (0.014), 2 = fencers are different from sprinters (p = 0.043), 3 = fencers are different from non-athletes (p = 0.025), 4 = fencers are different from non-athletes (p = 0.038), 5 = sprinters are different from table tennis (p = 0.021), 6 = sprinters are different from table tennis (p = 0.010), 7 = sprinters are different from table tennis (p = 0.017), 8 = fencers are different from non-athletes (p = 0.005) and fencers are different from sprinters (p = 0.044)

**Table 2:** Multivariable analysis of selected variables stratified by sport type while controlling for age

| Variable | Non-athletes (reference group) | Athletes (N=50) | | | | *p*-value for tests between subjects * | Observed power |
|---|---|---|---|---|---|---|---|
| | | Long distance runners | Sprinters | Fencers | Table tennis | | |
| Vertical jump (cm) | 52.1 ± 5.9 | 52.7 ± 8.7 | 60.4 ± 10.3 | 64.5 ± 7.2 | 57.8 ± 14.4 | 0.083 | 0.605 |
| Muscular power (Newton-meter per sec) | 3608.9 ± 653.7 | 3650.6 ± 683.8 | 4336.7 ± 772.1 | 4777.1 ± 681.8 | 4282.6 ± 1097.8 | 0.011 | 0.845 |
| Light reaction time (millisecond) | 0.487 ± 0.045 | 0.507 ± 0.127 | 0.467 ± 0.071 | 0.500 ± 0.064 | 0.462 ± 0.068 | 0.364 | 0.323 |
| Sound reaction time (millisecond) | 0.536 ± 0.047 | 0.496 ± 0.063 | 0.486 ± 0.156 | 0.511 ± 0.062 | 0.472 ± 0.095 | 0.618 | 0.203 |
| Choice reaction time-light (millisecond) | 0.560 ± 0.091 | 0.554 ± 0.106 | 0.533 ± 0.109 | 0.563 ± 0.078 | 0.557 ± 0.136 | 0.966 | 0.077 |
| Maximal anaerobic power (watts) | 729.4 ± 183.9 | 681.1 ± 117.1 | 826.0 ± 174.8 | 951.9 ± 210.9 | 807.3 ± 214.1 | 0.008 | 0.867 |
| Maximal anaerobic power (watts/kg) | 13.2 ± 1.7 | 12.3 ± 1.4 | 13.8 ± 1.9 | 14.8 ± 1.8 | 12.8 ± 2.6 | 0.066 | 0.641 |
| Average anaerobic power-30 sec (watts) | 428.4 ± 115.1 | 463.5 ± 69.5 | 517.9 ± 140.8 | 673.6 ± 163.8 | 529.2 ± 172.5 | 0.001 | 0.969 |
| Average anaerobic power-30 sec (watts/kg) | 7.7 ± 1.1 | 8.4 ± 1.1 | 8.7 ± 2.1 | 10.4 ± 1.4 | 8.4 ± 2.2 | 0.007 | 0.875 |
| Total work (Joule/ kg body weight) | 199.9 ± 10.5 | 207.8 ± 10.3 | 205.9 ± 16.9 | 208.4 ± 4.5 | 197.8 ± 24.9 | 0.455 | 0.273 |
| Fatigue index (watts/sec) | 17.7 ± 4.9 | 11.3 ± 4.0 | 18.7 ± 6.0 | 15.1 ± 6.7 | 14.4 ± 6.5 | 0.028 | 0.754 |

* Data are means and standard deviations. Roy's Largest Root p-value for the main effects of sport = 0.021 with an observed power = 0.941. The effect of age was also significant (p = 0.016) with an observed power of 0.949

Table 3 shows the results of partial correlation coefficients of selected anthropometric variables with reaction time and anaerobic power indices among Saudi athletes while adjusting for the effect of age. Vertical jump showed a significant relationship with lean body mass (r=0.496, p<0.001), while muscular power measure was correlated significantly with BMI (r=0.635, p<0.001), the sum of skinfold thickness (r=0.298, p=0.040), and lean body mass (r=0.782, p<0.001). Absolute maximal anaerobic power and fatigue index correlated significantly with all measures of anthropometry.

Average anaerobic power in 30 seconds whether in absolute or relative to body weight value correlated significantly with lean body mass (r=0.775, p<0.001, and r=0.429, p=0.002, respectively).

**Table 3:** Partial correlations coefficients selected anthropometric variables with reaction time and anaerobic power among Saudi athletes while controlling for the effect of age

| Variable | BMI | Sum of skinfold thickness | Body fat percent | Lean body mass |
|---|---|---|---|---|
| Vertical Jump (cm) | 0.320 (0.027) | 0.018 (0.903) | -0.009 (0.954) | 0.496 (<0.001) |
| Muscular power (Newton-meter per sec) | 0.635 (< 0.001) | 0.298 (0.040) | 0.276 (0.057) | 0.782 (< 0.001) |
| Light Reaction time (millisecond) | -0.0180 (0.222) | - 0.212 (0.148) | -0.176 (0.230) | - 0.089 (0.546) |
| Sound Reaction time (millisecond) | 0.089 (0.547) | 0.046 (0.755) | 0.049 (0.741) | 0.125 (0.398) |
| Choice Reaction time-light (millisecond) | -0.144 (0.329) | - 0.129 (0.381) | -0.083 (0.576) | - 0.094 (0.526) |
| Maximal anaerobic Power (watts) | 0.692 (< 0.001) | 0.409 (0.040) | 0.398 (0.005) | 0.885 (< 0.001) |
| Maximal anaerobic Power (watts/kg) | 0.293 (0.043) | 0.072 (0.625) | 0.055 (0.710) | 0.456 (0.001) |
| Average anaerobic power-30 sec (watts) | 0.497 (< 0.001) | 0.135 (0.359) | 0.118 (0.426) | 0.775 (< 0.001) |
| Average anaerobic power-30 sec (watts/kg) | 0.105 (0.479) | - 0.236 (0.106) | - 0.257 (0.078) | 0.429 (0.002) |
| Fatigue Index (watts/sec) | 0.407 (0.004) | 0.289 (0.047) | 0.301 (0.037) | 0.372 (0.009) |

Finally, Table 4 presents the findings of the partial correlation coefficients of Saudi athletes for measures of reaction time with anaerobic power variables while controlling for the effect of age. Only the fatigue index correlated significantly and negatively with reaction-movement time using light (r=-0.301, p=0.038). In addition, the following interesting significant relationships were also seen (not presented in Table 4). Choice reaction time (light) correlated with simple reaction time to light (r=0.545, p<0.001), and simple reaction time to sound (r=0.366, p=0.011). Simple reaction time to light correlated with simple reaction time to sound (r=0.282, p=0.052). Further, maximal anaerobic power relative to body weight correlated significantly with the average anaerobic power in 30 second relative to body weight (r=0.476, p=0.001), with fatigue index (r=0.685, p<0.001), and with vertical jump (r=0.427, p=0.002), while fatigue index correlated significantly with vertical hump (r=0.307, p=0.034).

**Table 4:** Partial correlations coefficients of reaction time with anaerobic power variables among Saudi athletes while controlling for the effect of age

| Variable | Light reaction time | Sound reaction time s | Choice reaction time-light |
|---|---|---|---|
| Vertical Jump (cm) | -0.130 (0.378) | 0.020 (0.892) | -0.134 (0.365) |
| Muscular power (Newton-meter per sec) | -0.155 (0.293) | 0.071 (0.631) | -0.143 (0.331) |
| Maximal anaerobic Power (watts) | -0.179 (0.223) | 0.101 (0.495) | -0.188 (0.200) |
| Maximal anaerobic Power (watts/kg) | -0.193 (0.190) | 0.022 (0.882) | -0.218 (0.137) |
| Average anaerobic power-30 sec (watts) | 0.054 (0.716) | 0.035 (0.815) | -0.086 (0.561) |
| Average anaerobic power-30 sec (watts/kg) | 0.138 (0.349) | - 0.013 (0.930) | -0.074 (0.617) |
| Fatigue Index (watts/sec) | -0.301 (0.038) | 0.088 (0.550) | -0.221 (0.133) |

## 4. Discussion

The best performance in various sports needs high anaerobic capacities. Certain sports demand the highest power or the absolute power output, independent of body size (Zupan et al., 2009). Combat performance is affected by several factors such as aerobic endurance (Durmic et al., 2017), anaerobic capacity (La Bounty et al., 2011), maximal strength, body composition (Braswell et al., 2010), and body proportions (Kirk, 2018) among others. Complex reaction times are major factors in elite sports. Reaction time in sports can affect the athlete's capability to improve performance, and concentration, and make suitable conclusions (Malhotra et al., 2015).

Up until now, anaerobic power testing (WAnT) studies with a large sample size have not been reported on Saudi elite athletes in different sports and there has been no classification system introduced for trainers to understand test results. The aim of the present study was to evaluate the associations of whole-body reaction time with anaerobic power performance among Saudi elite athletes in different sports. By using this, athletes can perform the WAnT and compare themselves to other athletes on a scale from "poor" to "elite."

To the best of our knowledge, this is the first study in Saudi Arabia that has investigated the effect of fatigue on reaction time, as well the investigation of the differences and associations between anaerobic power measures and simple and choice reaction movement times among four groups of elite young athletes relative to a reference group of non-athletes. The major results of this study demonstrated that there were no significant differences in reaction-movement time between long-distance runners, sprinters, fencers, table tennis players, or untrained students. This finding could be due to the fact that improvement in reaction times is not caused by performance level but improved by regular training (Chandra et al., 2015; Levitt and Gutin, 1971).

However, tests between subjects showed significant differences relative to sport type in muscular power, absolute maximal anaerobic power, absolute average anaerobic power in 30 seconds, average anaerobic power relative to body weight, and fatigue index. Fencers recorded the highest values in absolute anaerobic power, absolute average power in 30 seconds, and average anaerobic power relative to body mass. Sprinters showed the highest decrement in anaerobic power during the 30-second test (18.7±6.0 watts/sec). In addition, only the fatigue index correlated significantly and negatively with reaction-movement time using light. Also, maximal anaerobic power relative to body weight correlated significantly with the vertical jump test.

Our results closely reflect the data from various previous studies. Atan and Akyol (2014) have compared the reaction time values between the athletes involved in various sports. Football players had the fastest reaction time values however, they have lower auditory reaction time values than judokas players. Furthermore, simple right reaction time was found higher in judokas than in football and field track players. However, non-athletes reaction times were found higher than most of the athletes. No significant differences were found between the other sports branch athletes. Koç and Aslan (2010) could not find any change in reaction time, compared between handball players and volleyball players, this may be due to the similar age groups. In another study, Koç et al. (2011) confirmed that the reaction time of basketball players and handball players were not similar.

The previous study indicated that the reaction time of best-performing athletes is shorter than others; though the difference is not directly linked to their performance levels (Mero et al., 1992). It is reported that short reaction time may be due to physical training performed over a long period (Çolakoğlu et al., 1993). Chandra et al. (2010) determined the impact of exercise and heat strain on the reaction time in university students. Both auditory and visual reaction times were significantly decreased after the exercise however a marked increase was seen when the exercise was performed at high temperatures. In another study, it is identified that subjects performing exercises at a heart rate of 115 pulse/min have a faster reaction time (Levitt and Gutin, 1971). Furthermore, it is reported previously that physically fit individuals have faster reaction times (Welford, 1980).

It is also revealed in the research that reactions given to auditory stimuli are shorter than the reactions given to visual stimuli (Williams and Walmsley, 2000). It is also noticed in both groups that the source of sound is not important for faster auditory reaction times, it is only sufficient to hear the sound stimulus for the creation of the sensitivity, instead of that visual stimuli should be seen, therefore because of this reason reaction time may be longer.

### 4.1. Strength and limitations

The strength of the study included having many athletes from differing sports that require fast response rates and high anaerobic power. Including non-athlete individuals as a reference group is another strength of this study. On the other hand, the mode of anaerobic testing by cycle ergometer may not be specific for testing many of the sports used in this study. Moreover, precise information on the hours of sleep during the night preceding the testing of the participants was not recorded. A previous study's findings showed that short time sleep deprivation did not impact anaerobic performance, but adversely affect cognitive functions such as reaction time (Taheri and Arabameri, 2012).

## 5. Conclusion

The major findings of this study showed that there were no significant differences in reaction-movement time between long-distance runners, sprinters, fencers, table tennis players, or untrained university students. However, tests between subjects showed significant differences relative to sport type in muscular power, absolute maximal anaerobic power, absolute average anaerobic power in 30 seconds, average anaerobic power relative to body weight, and fatigue index.

The current findings will enhance the growing body of literature on sound and light reaction time involving an elite Saudi athletic population. This study will permit trainers, athletes, and scientists to use these results as tools to assess power output and provide evaluations from a set of authentic standards. Furthermore, this information will help to create a charter by which athletes can compare their performance on the WAnT.

With the growing interest among coaches and sports physiologists in the importance of visual reaction time and audio time, more future research should be conducted, and the refinement of an athlete's visual and audial function in relation to their sports performance be further investigated.

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## Compliance with ethical standards

## Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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