The role of anthropometry, physical, psychological and personality for elite athletes in competitive sports

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Abstract
Background and Study Aim
This study aims to describe and explore the anthropometric, physical, psychological, and personality traits of elite Papuan Indonesian athletes in seven different sports, namely weightlifting, rowing, cricket, futsal gateball, sailing, and hang-gliding.

Material and Methods
A total of 118 athletes (80 men, 38 women with a mean age of 25.05±6.9) from these seven categories were selected. Furthermore, the anthropometric measurement consists of height, weight, and body mass index. At the same time, physical ability is made up of five components, namely flexibility, arm muscle strength, abdominal muscle strength, leg muscle power, and aerobic endurance. The psychological ability and personality characteristics were also measured using the Psychological Skill Inventory for Sport (PSIS) and the Athlete’s Personality Inventory (IKA).

Results
There were significant differences in the six variables (p<0.01), but no significant difference in the other variables (p>0.05). The six variables include height, BMI, arm and abdominal muscle strength, leg muscle power, and aerobic endurance with F and p-values of 3.052 and 0.008 (p<0.01), 3.497 and 0.003 (p<0.01), 9.822 and 0.001 (p<0.01), 11.855 and .001 (p<0.01), 52.747 and 0.001 (p<0.01), and 11.298 and 0.001 (p<0.01). The other four variables include weight, flexibility, psychological abilities, and personality traits, showed no significant difference (p>0.05). Aerobic endurance variables, in general, had a significant relationship with anthropometric variables and other physical aspects. However, psychological variables and personality characteristics did not significantly correlate with other variables.

Conclusions
The anthropometric and physical aspects of athletes tended to have differences based on sports. However, psychological variables and personality characteristics had no relationship with physical and anthropometric aspects.

Keywords: anthropometric, physical abilities, psychological skills, personality, elite athletes

Introduction
The performance level of athlete is based on multifactorial influences such as anthropometric and physical abilities [1, 2, 3], psychological, mental, personality [4, 5, 6], coaches [7, 8], and the environment [9, 10]. These factors are interrelated and influence the performance of athletes on the field [11, 12, 13]. Data from previous studies reported that anthropometric factors [14, 15], physical abilities, psychological [16], are very important for an athlete to be successful professionally at the competitive sports level in the future. There are at least three primary factors that influence the performance of athletes in the field, namely anthropometrics, physical, and psychological abilities [17,18]. The anthropometric aspect deals with body measurements such as height, weight, arm length, with various urgency levels within sports [19]. While the physiological traits are related to motoric potential and abilities [20], such as speed, strength, agility, and endurance, and are greatly influenced by a person’s physiological condition. However, the psychological aspect is related to mental readiness and the ability to practice and compete for achievement [21]. Many studies have conducted an anthropometric analysis because they believe it perfectly describes the performance and achievements of athletes [17, 22, 23]. Furthermore, each sport has different anthropometric needs that support specific skills. For example, goalkeepers in futsal require higher height characteristics compared to weightlifting. In contrast, body weight tends to be more needed in weight lifting to support athletes in lifting relatively heavy weights.

Physical ability is commonly referred to as physiological, which is an important aspect of competitive sports [24, 25, 26]. Excellent physical could assist athletes play optimally, which supports them to obtain higher achievements [27]. In several

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game sports such as futsal, cricket, and football, a physical condition such as aerobic endurance plays a major factor since the game lasts for a long period [28]. Therefore, these athletes need to have a higher VO2max than other athletes in hang-gliding, sailing, and weightlifting. However, arm muscle strength is more required in weightlifting and rowing than futsal and gate ball.

The psychological aspect of athletes is part of the dimensions that greatly determine a competition's outcome [16, 29, 30]. In the event that an athlete feels anxious or unconfident, their skills and good physical condition become ineffectual [31]. According to Lange-Smith, Cabot, Coffee, Gunnell & Tod [32], the key factor to be able to have high performance and compete and be successful in competitive sports is managing the psychological aspect as well as possible. Unfortunately, the psychological aspect is often overlooked because most trainers or coaches focus on building the physical features. Therefore, this psychological aspect often becomes a "scapegoat" for failing to achieve the laid down goals and unsatisfactory performance.

Previous studies have shown that personality characteristic is one of the many factors contributing to an individual's success, especially in sports [33, 34, 35]. Basically personality is closely related to the behavior or actions of athletes when training or when competing. For example, athletes with good personality will have respect for friends, coaches or opponents. Conversely, a bad personality will make the athlete never achieve high success [36]. Data from previous studies reported that personality has a positive relationship with performance in sports [37].

Comprehensively studying the anthropometric, physical, psychological, and personality aspects of athletes from various sports provided more beneficial information. This means it had limitations in the previous studies, which only partially examined every element related to athletes. Researchers had not found any studies that comprehensively investigated athletes' anthropometric aspects, physical fitness, personality characteristics, and psychology. These were essential aspects to enhance performance among athletes. Based on the above description, this study aims to describe and explore in the anthropometric, physical, psychological, and personality traits of elite Papuan Indonesian athletes in seven different sports.

Materials and Methods

Participants

This study used subjects that included elite athletes from Papua Indonesia who was undergoing training to prepare for Indonesia's biggest national sports event, called the XXth National Sports Week (PON). Furthermore, a total of 118 athletes (mean age: 25.05±6.9 years) from seven different sports were involved in this study, namely 18 in Weight lifting (10 males, 9 females), 15 in Cricket (9 males, 6 females), 30 in Rowing (18 males, 12 females), 10 in Futsal (10 males), 15 in Gateball (15 males, 2 females), 19 in Sailing (12 males, 7 females) and 11 in Hang-gliding (8 males, 3 females).

Research Design

Anthropometric characteristics were determined based on height, weight, and Body Mass Index (BMI). The height was measured using a stadiometer (Seca 213; Seca, Japan) nearest 0.1 cm. While the bodyweight was measured using a digital weight scale (HBF-214; Omron, Japan) to the nearest 0.1 kg, and the BMI was calculated based on body weight and height (BW/H²).

Furthermore, the physical ability (physiological) was measured using five components: flexibility, arm and abdominal muscle strength, leg muscle power, and aerobic endurance. Flexibility was estimated using a vertical trunk flexion meter (TKK 5403; Takei, Japan) to the nearest 0.1 cm. At the same time, the Abdominal and arm muscle strength was measured by doing sit-ups and push-ups for 60 seconds (TKK 5503; Takei, Japan) [38]. The Leg muscle power was measured three times using the vertical jump test [39], and the best results were recorded to the nearest of 0.1 cm. In addition, the aerobic endurance was measured using a multi-stage run 20m test [40].

The psychological ability was determined using the Psychological Skill Inventory for Sport (PSIS) [41] and has been adapted in Indonesian by Dimyati, Herwin, & Hastuti [42], with a validity and reliability value between 0.54 to 0.89 and 0.8 to 0.92. Furthermore, the personality characteristics were found using the Athlete Personality Inventory (IKA) [43].

Statistical Analysis

Data were analyzed using descriptive techniques such as mean±Standard Deviation (SD) using the minimum and maximum values. While further statistical analysis was carried out using the one-way analysis of variance (One-way ANOVA) and to determine the relationships between the variables, Pearson's product-moment correlation analysis was employed. The accepted level of statistical significance was p<0.05, and all data analyses were performed with the assistance of the IBM SPSS version 26 program (Armonk, NY, USA: IBM Corp.).

Results

The first analysis results were presented descriptively using the minimum, maximum, average, and standard deviation values (Table 1). The results show that the age of elite athletes undergoing training was between the ages of 17 to 48, with an
average value of 25.05±6.9. In the anthropometric aspect, the athlete’s height and body weight was between 158 to 183cm and 43.5 to 120.6kg with an average value of 163.39±8.01, and 67.5±13.49, while BMI was between 17.39 to 43.4 kg/m² with a mean value of 25.27±4.58. Furthermore, for physical and flexibility aspects, arm and abdominal muscle strength, leg muscle power, aerobic endurance, arm muscle strength, abdominal muscle strength had values between 1.5 to 27 cm, 11 to 56, 11-68, 9.7-144 cm, 20.4-54.1 ml/kg/min with an average value of 11.94±5.53, 38.98±9.12 and 20.4-54.1 ml/kg/min. The psychological ability dimension had a value in the range of 68 to 174, with an average value of 131.86±17.78. In addition, the personality characteristics scored 144 to 240 with an average value of 205.5±18.29.

The height, IMT, arm and abdominal muscle strength, leg muscle power, and aerobic endurance variables showed a statistically significant difference with a F and Sig. values of 3.052 and 0.008 (p<0.01), 3.497 and 0.003 (p<0.01), 9.822 and 0.001 (p<0.01), 11.855 and 0.001 (p<0.01), and 52.747 and 0.001 (p<0.01). However, the variables of psychological ability, weight, flexibility and personality characteristics had no statistically significant difference with an F and Sig. values of 0.568 and 0.755 (p>0.05), 1.096 and 0.370 (p>0.05), 0.865 and 0.523 (p>0.05) (Table 2).

The summary of the relationship analysis among the variables is presented in Table 3. Based on the analysis results, several variables had a significant relationship, but the others did not have relationship. Endurance variables, in general, had a significant relationship with anthropometric variables and other physical aspects. Psychological variables and personality characteristics did not significantly correlate with other variables.

**Discussion**

Statistically, the result found significant differences in six categories and no difference in the other four categories. First, there were significant differences in height since each sport has different requirements (anthropometrics) [15]. Therefore, it was one of the criteria assessed by the coach in the selection process for elite athletes in Indonesia. The determination of the height criteria between coaches of one sport and another was certainly different due to their requirements and the characteristics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Weightlifting (M±SD)</th>
<th>Cricket (M±SD)</th>
<th>Rowing (M±SD)</th>
<th>Futsal (M±SD)</th>
<th>Gateball (M±SD)</th>
<th>Sailing (M±SD)</th>
<th>Hang-Gliding (M±SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (year)</td>
<td>31.22±.51</td>
<td>23.80±5.13</td>
<td>20.27±2.8</td>
<td>19.90±.876</td>
<td>32.40±8.05</td>
<td>24.50±3.85</td>
<td>25.91±4.13</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>157.79±8.26</td>
<td>161.86±10.92</td>
<td>166.37±6.89</td>
<td>165.18±6.08</td>
<td>165.59±8.84</td>
<td>162.72±6.77</td>
<td>166.84±7.47</td>
</tr>
<tr>
<td>Wight (kg)</td>
<td>70.48±5.81</td>
<td>63.23±11.52</td>
<td>65.04±9.92</td>
<td>65.44±11.56</td>
<td>67.62±12.14</td>
<td>72.78±16.92</td>
<td>68.14±9.61</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>28.13±18.93</td>
<td>24.17±3.93</td>
<td>23.41±2.63</td>
<td>23.95±3.76</td>
<td>25.26±3.97</td>
<td>27.60±5.52</td>
<td>24.52±3.45</td>
</tr>
<tr>
<td>Flexibility (cm)</td>
<td>13.45±6.28</td>
<td>10.40±7.37</td>
<td>12.65±4.86</td>
<td>11.00±5.63</td>
<td>10.17±6.03</td>
<td>11.89±4.42</td>
<td>13.00±5.85</td>
</tr>
<tr>
<td>Arm muscle strength (kg)</td>
<td>34.50±5.35</td>
<td>35.87±7.31</td>
<td>42.87±8.08</td>
<td>44.50±5.87</td>
<td>28.53±7.23</td>
<td>43.74±8.64</td>
<td>41.00±6.40</td>
</tr>
<tr>
<td>Abdominal muscle strength (s)</td>
<td>42.61±7.34</td>
<td>31.60±6.63</td>
<td>41.10±10.44</td>
<td>26.60±6.78</td>
<td>21.27±5.72</td>
<td>31.42±7.80</td>
<td>38.82±10.98</td>
</tr>
<tr>
<td>Leg muscle power (cm)</td>
<td>52.94±12.84</td>
<td>47.00±7.82</td>
<td>47.66±9.12</td>
<td>52.60±5.92</td>
<td>40.28±13.32</td>
<td>105.47±20.32</td>
<td>48.82±11.75</td>
</tr>
<tr>
<td>Aerobic endurance (ml/kg/min)</td>
<td>26.50±15.55</td>
<td>32.03±5.13</td>
<td>39.25±7.89</td>
<td>45.28±6.91</td>
<td>30.31±7.54</td>
<td>37.62±8.33</td>
<td>40.23±9.71</td>
</tr>
<tr>
<td>Psychological abilities (points)</td>
<td>153.11±5.71</td>
<td>131.87±16.54</td>
<td>134.13±20.45</td>
<td>157.10±12.76</td>
<td>127.15±17.05</td>
<td>127.84±13.65</td>
<td>132.18±22.41</td>
</tr>
<tr>
<td>Personality characteristics (points)</td>
<td>205.44±18.78</td>
<td>196.73±16.59</td>
<td>207.40±16.21</td>
<td>206.30±14.91</td>
<td>207.00±15.42</td>
<td>207.16±18.25</td>
<td>206.91±23.24</td>
</tr>
</tbody>
</table>
of Physical Culture and Sports

Reilly et al. [44] also mentioned that each sport's anthropometric characteristics (height) were diverse; for example, the average height of elite rugby and soccer athletes was 1.79±0.06 and 1.77±0.06. Itoh & Hirose [45] studied athletes' anthropometrics and found significant differences in the height category. In certain sports, such as football, the height between the goalkeepers, attackers, and midfielders were mostly different [44]. This means that the height requirements of athletes in each sport, including playing position, were also different [45].

Furthermore, the results showed that there was a significant difference in BMI. This is supported by the study conducted by Putra and Ita [49], who compared the BMI of athletes in three different sports. The difference in the criteria for ideal body weight in each sport was believed as a factor that contributed to those results. For example, weightlifting requires a relatively heavier body weight than other sports like gliding and sailing. Weightlifters weigh more than any other athletes and even weigh up to 120.60 kg. In contrast with the BMI results, no significant difference was found in the flexibility variable. This is due to the long training process that had been conducted by athletes before entering the camp. They all trained individually and at their respective clubs. Furthermore, these results were

| Table 2. The test result of anthropometric, physical capacity, psychological abilities, and personality |
|-------------------------------|------------------|--------|---------|
| Variable                      | Mean ± S.D       | F      | Sig.    |
| Height (cm)                   | 163.4 ± 8.01     | 3.052  | 0.008*  |
| Wight (kg)                    | 67.54 ± 15.49    | 1.096  | 0.370*s |
| BMI (kg/m²)                   | 25.28 ± 4.58     | 3.497  | 0.003*  |
| Flexibility (cm)              | 11.94 ± 5.55     | 0.865  | 0.001*  |
| Arm muscle strength (kg)      | 38.98 ± 9.12     | 9.822  | 0.001*  |
| Abdominal muscle strength (s) | 34.60 ± 11.7     | 11.855 | 0.001*  |
| Leg muscle power (cm)         | 57.28 ± 25.01    | 52.747 | 0.001*  |
| Aerobic endurance (ml/kg/min) | 35.59 ± 9.1      | 11.298 | 0.001*  |
| Psychological abilities       | 131.86 ± 17.78   | 0.568  | 0.672 *s|
| Personality characteristics   | 205.52 ± 18.2    | 0.673  | 0.755 *s|

Notes: *p < .01; *Correlation is significant at the 0.05 level (2-tailed)

| Table 3. Correlation test results between variables |
|-------------------------------|------------------|--------|---------|
| Variable                      | 1                | 2      | 3       | 4       | 5       | 6       | 7       | 8       | 9       | 10      |
| 1. Height (cm)                | -                |        |         |         |         |         |         |         |         |         |
| 2. Wight (kg)                 | 0.413*           | -      |         |         |         |         |         |         |         |         |
| 3. BMI (kg/m²)                | -0.093           | 0.866* | -       |         |         |         |         |         |         |         |
| 4. Flexibility (cm)           | -0.059           | -0.024 | 0.001   | -       |         |         |         |         |         |         |
| 5. Arm muscle strength (kg)   | 0.266*           | 0.029  | -0.115  | -0.067  | -       |         |         |         |         |         |
| 6. Abdominal muscle strength (s)| -0.090           | -0.128 | -0.092  | 0.136   | 0.381*  | -       |         |         |         |         |
| 7. Leg muscle power (cm)      | 0.048            | 0.090  | 0.073   | 0.003   | 0.389*  | 0.058  | -       |         |         |         |
| 8. Aerobic endurance (ml/kg/min)| 0.356*           | -0.165 | -0.367* | -0.022  | 0.652*  | 0.227   | 0.310*  | -       |         |         |
| 9. Psychological abilities   | 0.171            | 0.088  | -0.006  | 0.019   | -0.040  | 0.039   | -0.143  | 0.102   | -       |         |
| 10. Personality characteristics (points) | 0.143            | 0.068  | -0.010  | 0.087   | 0.141   | 0.135   | 0.082   | 0.138   | 0.064   | -       |

Note: **Correlation is significant at the 0.01 level (2-tailed); *Correlation is significant at the 0.05 level (2-tailed)
supported by the studies of Itoh & Hirose [45], who found no significant difference in flexibility. A significant difference was found in the arm muscle strength variable due to differences in the physical ability requirements in each sport. For example, weightlifting, rowing, and cricket require greater arm muscle strength than futsal, hang-gliding, and sailing [50]. Under these conditions, athletes must train rigorously to increase their arm muscle strength. Conversely, futsal athletes would also focus more on the physical aspects such as aerobic endurance, speed, agility, and leg muscle power since these physical dimensions are required.

The research data shows that the results of rowing, weightlifting, and cricket athletes were higher than other athletes. However, the results of this study are different from previous study which was conducted by Putra and Ita [49]; there was no significant difference in the arm muscle strength of the athletes in three different sports. Their research reported that data collection was carried out when the athletes had just begun their training concentration programs. This means they had not received any intensive program from the coach concerning physical exercise. However, this study was carried out when the athletes underwent an intensive training program. The research subjects involved were also from different sports. Therefore, it was natural to find different results between the two studies. The study conducted by Vukasevic et al. [51] found no significant difference in the arm muscle strength (push-ups) category. However, there were subject differences between Vukasevic et al and this study, and this is because they compared athletes in the same sport.

There was a significant difference in the abdominal muscle strength variable due to the characteristics of the sport. This is supported by the research data, which shows that the mean value of rowing and weightlifting athletes (M=41.85±11.6) was higher than the average score (M=54.6±11.6). Previous studies have shown that the strength of the abdominal muscles greatly enhances the performance of rowing athletes and weightlifters. However, these results differ from Vukasevic et al [51], whereby there was no statistical difference in the abdominal muscle strength variable. In addition, the difference between the two research results could not be separated from the differences in the subjects studied.

There was a significant difference in the leg muscle power variable. This is supported by the research conducted by Kobal et al. [52], in four different sports and is also in line with Gall et al. (2010). The reason behind these results was that the seven sports sampled in the study had different game characteristics and physical needs, which affected the physical capacity of the athletes [47]. For example, futsal athletes need leg power muscle strength to improve their performance on the field, especially when performing kicks and running. However, this is different for the hang-gliding and sailing athletes in which do not require leg muscle power. However, the results of these studies differ from that of Vukasevic et al. [51], whereby there was no significant difference in the leg muscle power of the athletes. Furthermore, the difference in research results was due to the number of sports studied. Significant differences are mostly found in studies that involve several sports [52], compared to those involving one sport.

There was a significant difference in the aerobic endurance variable due to the characteristics of the sport under study. Weightlifting, cricket, rowing, futsal, gateball, sailing, and hang-gliding have different playing methods and require different aerobic endurance. For example, futsal, rowing, cricket, and gateball require a higher physical capacity (aerobic endurance) than hang-gliding, sailing, and weightlifting. These results are supported by previous research conducted on athletes from Papua, Indonesia, which showed significant differences in the aerobic endurance variable [49]. However, a different result was found in Lopez-Plaza et al. [53], whereby they investigated rowing athletes and found no differences in aerobic endurance. The study only compared the numbers in rowing and not between sports. Therefore, there was a tendency to have the same physical capacity (aerobic endurance).

This study found no difference in the psychological abilities of athletes because Indonesian National Sports Committee made a policy or program called “Character Building and Achievement Motivation Training” (CB-AMT) by involving experts in the field of sports psychology. Furthermore, the program’s main objective was to form a winning mentality for Papuan athletes [54]. All those undergoing training were required to participate in the CB-AMT. The program was acknowledged as a factor that causes elite Papuan athletes to be at a relatively similar psychological level. However, this study did not analyze and reveal its role in the psychological condition of the athletes [51].

The next results of this study found no differences in the personality characteristics in elite athletes from Papua, Indonesia. The “elite” status indicates that the athletes studied were a set of selected individuals, and not all of them could enter this level because they had to compete among themselves. Furthermore, those involved were psychologically strong and were tested, and there was no difference when measured using the Athlete’s Personality Inventory (IKA). This result is in line with the study conducted by Gunstor et al. [55], whereby there were no differences in athletes’ personality characteristics in four different sports. It was due to the similarity level in terms of mentality. However,
the results would differ if the research subjects were compared between several groups, such as elite and non-elite athletes and non-athletes.

The result of the correlation analysis among variables shows that, in general, the aspect of endurance had a significant relationship with anthropometric variables (BMI) and other physical capacities. This strengthened the previous evidence that endurance capacity was a key and supporting aspect of several other physical components [28, 24, 27]. Different results were found on psychological and personality variables. The two variables did not have a significant relationship with other variables. Previous study found that psychological and personality dimensions have a relationship with the physical capacity of athletes [56]. However, that study were conducted on one sport and involving only 12 athletes. This was very different from the current research which involved various sports and a lot of athletes.

A number of important limitations need to be considered. First, the tests or measurements were only carried out once. Therefore, further research needs to be conducted by performing several tests or measurements. For example, in four weeks, the same retest was conducted to evaluate the changes that had been occurred, both physically and psychologically, since they were dynamic. Secondly, the characteristics of the sports did not represent the other four type of sports, namely martial arts, games, accuracy, and measurability. Therefore, further studies need to involve more sports and athletes to obtain more comprehensive information. Finally, coaches, sports administrators, and athletes can use this result to improve less than ideal conditions. This is very important because anthropometric aspects, physical, psychological, and personality capacities affect an athlete’s performance in the field.

Conclusions

There were significant differences in the six variables, but the others was not different. The six variables include height, BMI, arm and abdominal muscle strength, leg muscle power, and aerobic endurance. The other four variables which include weight, flexibility, psychological abilities, and personality traits, showed no significant difference. Endurance variables, in general, have a significant relationship with anthropometric variables and other physical aspects. However, psychological variables and personality characteristics do not significantly correlate with other variables. Thus, the anthropometric and physical aspects of athletes tend to have differences based on sports. However, psychological variables and personality characteristics did not have relationship with physical and anthropometric aspects.

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Conflict of interest

No conflict of interest in this research.

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