International Journal of Strength and Conditioning

Does Place of Birth Affect the Anthropometric and Performance Characteristics of Papua New Guinean Athletes?

Kieran Sciberras[1,2], Glen B. Deakin[1], Aaron Alsop[2] and Stephen P. Bird[3]

[1]Sport and Exercise Science, James Cook University, Cairns, Australia, [2]Papua New Guinea Sports Foundation, Port Moresby, Papua New Guinea, [3]School of Health and Medical Sciences, University of Southern Queensland, Ipswich, Australia.

ABSTRACT

Previous research has indicated that region of origin may influence the anthropometric and performance characteristics of an individual. The aim of this study was to determine the anthropometric and performance characteristics of Papua New Guineans and examine the relationship with the region of origin. 1176 Papua New Guinean athletes (666 males/510 females) aged between 14 and 39 years old completed anthropometric testing (height, seated height, arm span, body mass, body mass index), performance testing (sit and reach, medicine ball throw, vertical jump, Illinois agility, 5m/20m sprint, 60 second push-up/sit-up, multi-stage fitness test) and a heritage questionnaire (participant's place of birth). Participants that met required criteria were categorised by ages groups (15-17 years, 18-20 years, 21-25 years and 26-30 years), sex (male and female) and by birth province (National Capital District, Morobe, Central, Sandaun, East Sepik, East New Britain, West New Britain and Milne Bay) before statistical analysis. Significant differences between birth provinces of participants were found for all tested anthropometric and performance characteristics ($p<0.05$), except for the leg length and Illinois agility test. Significant differences ($p<0.05$) were also found for all but one (body mass index) tested characteristics between the two sexes. Analysis of age indicated a significant difference for tested characteristics between age groups ($p<0.05$). Further analyses revealed that while birth province had an effect on some characteristics, sex and age demonstrated a significant and larger influence. Consequently, whilst there may be an association between the region of origin and anthropometric and performance characteristics of Papua New Guinean athletes, other variables such as sex and age also significantly influence anthropometric and performance characteristics.

Keywords: Talent identification, athletic performance, Pacific sport, sport performance, Papua New Guinea

INTRODUCTION

Historically, there has been constant discussion as to whether people are born with talent or if it is developed through different training interventions (1). Recently, it has become apparent that a variety of factors can influence a person's ability to excel athletically (2). Regardless of the sport that is chosen one characteristic that all sport requires is athletic talent. Athletic talent is the ability of a person to perform tasks related to their sport (3). Athletic talent is influenced by primary and secondary factors (4), these factors are vital for performance in sport. Primary factors are those, which the athlete contributes to their own performance (e.g. genetic influence, place of birth), whereas secondary factors are attributed to external sources (e.g. social and environmental factors) (4, 5).

Previous research has highlighted the roles that primary and secondary factors play in the development of athletic talent (6, 7). A study conducted on elite Kenyan distance runners concluded that a majority of National and International runners were born within the Rift Valley region and belonged to a specific ethnic group and sub-tribe within the region (6). Furthermore, in 2016, researchers Irving and Bourne determined that a combination of factors including genetics, family heritage, social determinants, environmental factors and place of residence improved chances of being selected for elite games and winning medals for Jamaican athletes (5). Two methods of determining the level of a person's athletic talent are 1) Talent identification (TID); and 2) Talent detection (TD). TID is defined as the identifying of current participants with the potential to excel in a certain sport (8) whilst TD is the discovery of potential athletes who are not currently involved in the sport (9). Typically, TID/TD programs involve administration of tests focusing on a combination of physiological, physical, anthropometric and/or technical attributes amongst designated sex and age groups (10). The goal of these programs is to find persons who have displayed athletic talent and provide them with the opportunity to excel within a sport or in a role within a sport (11, 12).

Examples of TID/TD programs can be seen all over the developed world, such as Qatar's Aspire Academy (13) and Australia's National Talent Search (NTS) program conducted in the lead up to the 2000 Sydney Olympics. The NTS examined and tested children aged between 14 and 16 for body size and athletic talent. The program was seen as a great success as Australia took home 3.03 medals per every million citizens (14). This leads to the question, could such a successful program be replicated in a Pacific Island country as diverse as Papua New Guinea (PNG)?

PNG has a population of over seven million people spread throughout 22 different provinces (15). The country has a diverse geography with landscapes varying between high altitude mountainous regions and low altitude coastal regions (16). Even more diverse than the geography of the country is its language base, with over 900 spoken languages and dialects (17). In a country with different environmental communities (cities, mountains and seaside), varied genetic backgrounds and unique cultural-social structures, there could be a diverse range of athletic talent. Research in the fields of TID and TD has not yet been conducted in PNG, more specifically, the anthropometric and performance characteristics of people from different regions within the country are yet to be determined. As PNG does not have the same resources and funding of athlete development and identification as developed countries, it would be of significant benefit to know which areas of the country host specific types of athletic talent to target future investment. Due to the varied genetic and environmental influences, cultural beliefs and a range of other already discussed factors linked to an athlete's place of birth or region of origin, there are potentially a large number of undiscovered potentially talented athletes in PNG.

Therefore, the two primary aims of the current study were to: 1) examine anthropometrics and performance characteristics of Papua New Guinean athletes and community dwelling persons; and 2) determine whether there is a relationship between the anthropometric and performance characteristics and the participant's region of origin. It was hypothesized that participants from certain regions in PNG will display anthropometric and performance characteristics specific to those regions.

METHODS

Participants

One thousand, one hundred and seventy-six (1176) male (56.6%) and female (43.4%) participants aged between 14 and 39 years old participated in the study. Participants ranged from novices and provincial level athletes through to national representatives. All participation in this project was voluntary. Prior to the start of any data collection, participants, legal guardians and community leaders were briefed on the project by the principal investigator who outlined the aims, protocols and significance of the project. All participants and guardians completed informed consent forms and health and screening questionnaires, with only those deemed healthy and able by qualified Sports Medicine professionals, allowed to participate. The study was approved by the James Cook University Human Research Ethics Committee.

Heritage Questionnaire

All participants completed a heritage questionnaire, similar to that used in a prior heritage study (5).

Participants were required to answer the following questions, which were written in English and PNG's national language of Tok Pisin:

1. In which village/town and province were you born?
2. In which village/town and province did you spend most of your childhood?
3. In which village/town and province was your mother born in?
4. In which village/town and province was your father born in?
5. Where do you currently live (village/town and province) and how long have you lived there?

Testing Session Structure

Fitness testing sessions consisted of a battery of tests completed in the order of least fatiguing to most fatiguing. The test order consisted of anthropometric, flexibility, power, agility, speed, muscular endurance and aerobic endurance measurements for all sessions. After the completion of the anthropometric measurements, participants completed a standardised 10-minute warm-up consisting of light jogging, basic warm up drills (e.g. high knees, side steps) and dynamic stretching (e.g. leg swings, arm circles). For all performance tests, participants were given a practice attempt (e.g. two push-up repetitions to check form, Illinois agility test run through) before completing their recorded attempts. All testing sessions were completed within one day, with testing sessions conducted in various towns and communities over a 12-month period.

Anthropometric Measurements

Anthropometric measurements for height, seated height, body mass, arm span and body mass index (BMI) were recorded using a stadiometer, electronic scales and a tape measure, respectively (18). To measure height, the participant stood erect in bare feet with heels, buttocks and shoulders pressed against the stadiometer. The participant took a deep breath in and stood as tall as possible, while the measuring bar was moved down to the participant's head and height was recorded to the nearest 0.1cm. Following this, the participant sat with their knees slightly bent and hands rested on their knees. The buttocks and shoulders were pressed lightly against the stadiometer (HART Sport, Aspley, Australia), and once seated fully upright, the participant took a breath in and the measuring bar was moved down to the participant's head with the height recorded to the nearest 0.1cm. To measure body mass, participants wore sports clothing and stood in bare feet on electronic scales with body mass recorded to the nearest 0.1kg (Tanita Corporation, Tokyo, Japan). Finally, participants were required to lay supine on the ground with their shoulders in line with a floor mounted measuring tape. With arms extended laterally, one arm reaching as far as possible and the other aligned with the beginning of the tape, the distance between the two tips of the middle fingers was measured to the nearest 0.1cm to indicate arm span (adapted from Simmons; 18).

Flexibility and Power Testing

Flexibility of the hamstrings, trunk and hip joints were assessed through use of the sit and reach test. During this test, the participants removed their shoes before placing their feet against the sit and reach apparatus. Participants then reached as far forward as possible, with the most distant point reached with the fingertips being held for three seconds. The best of three attempts was recorded to the nearest centimetre (19). Upper body power was assessed using a medicine ball chest throw (Mb throw). For this test, participants stood upright with their feet together and heels touching the wall. Participants had three attempts to throw a four-kilogram medicine ball as far as possible without their knees bending or feet breaking contact with the ground or the wall. Distance was recorded to the nearest 0.1 metres (20). Lower body power assessment was conducted using a vertical jump device (Swift Performance Yardstick, Northbrook, IL). The participant's vertical reach was recorded, after which they completed three singular maximal countermovement jumps, with the highest result recorded to the nearest centimetre. To determine vertical jump height, the difference between the participant's reach and highest jump height was calculated (21).

Agility and Speed Testing

The Illinois agility test was used to measure each participant's change of direction speed. This test involved participants running up and down a 9.14m track on a suitable surface (e.g. court, running track or grass) before weaving in between four evenly spaced cones as fast as possible (22). Participants were allowed three attempts and were timed by test administrators using a handheld stopwatch, with their quickest time recorded. To ensure consistency of recorded results, the same test administrator was used for all attempts. Speed was measured using electronic timing gates (Fusion Sport, Brisbane, Australia). Participants were required to begin from a staggered start, behind the pre-determined start line before sprinting 20 metres (m) as fast as possible between the electronic timing gates. Gates were set up at the start line, the 5m and 20m mark to allow recording of times over the 20m (23). Three attempts were allowed, with the fastest times for the 5m and 20m segments recorded.

Muscular Endurance Testing

The two tests used to assess muscular endurance were the 60-second push-up test and the 60-second sit-up test. For the push-up test, participants were required to complete as many push- ups as possible in a 60-second period. Only full push-ups with proper form were recorded, the participant's wrists were placed directly under their shoulders and participants were on their toes. To complete a full push-up the participant's chest was required to touch a foam block that was 9.5cm from the ground. Following this, elbows had to reach full extension for each repetition to be recorded. If the knees touched the ground at any time during the test, the timer would be stopped, and the test would cease. Participants were only allowed one attempt, with the number of completed push-ups performed being recorded modified from Harman (21). As with the push-up test, participants were given 60 seconds to complete as many sit-ups as possible. This test involved a partner holding the participant's feet, while the participant performed their sit-ups. To complete a sit-up the participant started with their hands resting on the side of their head, laying on their back with their elbows pointing out. The participant then flexed at the torso and rotated so that their elbow touched the top of the opposite knee at the top of the movement. The participant then returned to the starting position, completing one repetition before completing the same movement, this time with their other elbow touching the opposite knee. Once 60 seconds had finished, the number of full sit-ups completed was recorded (22). All repetitions were monitored by the research data collection team.

Aerobic Endurance Testing

The multi-stage fitness test (MSFT) was used to assess the aerobic capacity of participants. This test required the participant to run back and forth over the 20m course, touching the line at or before an audio signal was played through a speaker. The frequency of the sound increased as the test progressed. One attempt of this test was allowed, and the test was completed when the participant was no longer able to keep pace with the signal played on the audio file (24).

Statistical Analysis

Although further data was collected during the heritage questionnaire, only place of birth (province) has been analysed within this study. This is partially due to the previously established relationship between place of birth and anthropometric and performance characteristics (4,5,6) but also due to the large number of participants tested and the amount of data collected within the study.

Data were entered into the statistical package SPSS for windows (Version 25; Statistical Package for Social Science, Chicago, IL), which was utilized for all statistical analyses. Descriptive statistics are displayed as mean (± SD) for numerical variables and percentages for categorical variables. For all statistical analyses, an alpha level of 0.05 was set. It was necessary to apply participant selection criteria due to the disparity between the number of representatives within some provinces (e.g., Hela province, n=2, National Capital District, n =492) and age groups (low participant numbers for ages below 15 years old and between 31-39 years old). Consequently, only participants a) aged between 15-30 years old and b) born in a province with a sample size of 30 or more were accepted for analysis.

Thus, the number of participants was reduced to eight hundred and fifty-six (856) aged between 15 and 30 years old. The 856 (Male: 58.2%, Female: 41.8%) participants were born in the provinces of National Capital District (NCD, n= 412), Morobe (n=140), Central (n=84), Sandaun (n=31), East Sepik (ESP, n=53), East New Britain (ENB, n=51), West New Britain (WNB, n=53) and Milne Bay (MB, n=32). Data was placed into four pre-determined age groups (15-17 years old, 18-20 years old, 21-25 years old, 26-30 years old) and arranged by the participants' birth province (NCD, Morobe, Central, Sandaun, ESP, ENB, WNB and MB).

For subsequent descriptive analyses, associations between two categorical variables were assessed by exact versions of chi-square tests. Percentages were used to display categorical variable of sex, with the ratio of male to female participants presented. Numerical data were described by means and standard deviations since the underlying distributions proved to be normal. Test comparisons between one categorical (i.e. birth province, age group or sex) and one numerical variable (i.e. anthropometric or performance results) were conducted using one-way Analysis of variance (ANOVA) models. Post hoc tests with Bonferroni pairwise adjustments were then used to test for significant differences for anthropometric and performance variables between specific age groups.

Prior to bivariate and multivariate regression analyses, provincial groups were further divided into tiering based on participant numbers within each province. Provinces with the largest sample sizes (n>83; NCD, Morobe and Central) were classified as Tier 1, whereas the remaining provinces (n<54; Sandaun, ESP, ENB, WNB AND MB) were classified as Tier 2. For all regression analysis in the Tier 1 classification, NCD was used as a baseline as it had the highest number of participants. Tier 2 provinces were not considered for regression analyses, as the sample sizes were not sufficiently large enough to enable multivariate modelling. Bivariate analysis was conducted to determine the effect of birth province on tested anthropometric and performance variables. Multivariate analysis was then used to account for likely confounding caused by the other independent variables of age and sex. As this article aims to determine the effect of birth province on anthropometric and performance variables, only variables found to have an interaction with birth province are displayed in the results.

RESULTS

Age, anthropometric and performance characteristics by birth province

No significant difference was found for the characteristics of leg length (p=0.36) and Illinois agility performance (p=0.235) across the eight birth provinces (Table 1). A significant difference across provinces was found for sex, age and all remaining anthropometric and performance tests (Table 1, p<0.05).

Anthropometric and performance characteristics by sex and age group

A significant difference was found between sexes for all tested variables (p<0.001), with the exception of BMI (p=0.933) (Table 2). A significant difference was found across the four age groups for sex and all anthropometric and performance characteristics (p<0.05, Table 3). Post-hoc Bonferroni analysis indicated multiple significant differences for tested variables between the four specific age groups as indicated in Table 3.

Bivariate and multivariate analysis of anthropometric and performance characteristics by birth province, age group and sex - Tier 1 provinces

Results from the bivariate and multivariate linear regression analysis for Morobe vs. NCD (baseline) and Central vs. NCD (baseline) are displayed in Table 4 and Table 5, respectively.

Bivariate linear regression was used to predict body mass, BMI, Mb throw distance and 5m and 20m sprint times based on a participant being born in Morobe rather than NCD. Using Mb throw as an example (Table 4), an R^2 value of 0.029 (2.9%) was found and it was predicted that for every participant born in Morobe, a throw of 0.36m farther than those born in NCD would be recorded (p<0.001). To control for potential confounding factors of age and sex, multivariate regression was used. When analysed with age group and sex, the birth province effect of 0.36m for participants born in Morobe was reduced to 0.20m (p<0.001), and the R^2 value increased to 0.646 (64.6%).

Bivariate and multivariate linear regression to predict arm span, sit and reach, vertical jump and MSFT differences based on a participant being born in Central rather than NCD was also completed (Table 5). Using VJ as an example (Table 5), an R^2 value of 0.030 (3.0%) was found and it was predicted that for every participant born in Central, a VJ of 4.82cm higher than those born in NCD would be recorded (p<0.001). When multivariate analysis was used to control for potentially confounding factors of age and sex, the birth province effect of 4.82cm was reduced to 2.44cm (p<0.05), and the R^2 value increased to 0.542 (54.2%).

The results from bivariate and multivariate linear regression analysis (Table 4, Table 5) indicate that the factors of birth province, sex and age can have an effect on certain anthropometric and performance characteristics.

Table 1. Anthropometrics and performance tests by birth provinces.

Variable	No. of missing participants	Birth Province Central n=84	ENB n=51	ESP n=53	MB n=32	Morobe n=140	NCD n=412	Sandaun n=31	WNB n=53	*p*-value
Age (years)	0	21.5 (±3.5)	20.4 (±3.7)	19.8 (±3.7)	19.6 (±4.4)	18.8 (±2.5)	19.0 (±3.6)	22.0 (±3.6)	19.5 (±3.0)	$p<0.001$
Sex male/female (%)	12	67.9%/32.1%	56.9%/43.1%	73.6%/26.4%	58.1%/41.9%	67.2%/32.8%	53.5%/46.5%	63.3%/36.7%	37.7%/62.3%	$p=0.001$
Height (m)	16	1.69 (±0.78)	1.67 (±0.08)	1.64 (±0.07)	1.61 (±0.07)	1.66 (±0.08)	1.66 (±0.08)	1.61 (±0.08)	1.64 (±0.08)	$p<0.001$
Leg length (m)	20	0.84 (±0.05)	0.85 (±0.05)	0.83 (±0.06)	0.82 (±0.05)	0.84 (±0.06)	0.83 (±0.06)	0.82 (±0.06)	0.83 (±0.06)	$p=0.36$
Body mass (kg)	21	64.12 (±8.97)	61.50 (±9.80)	60.88 (±10.67)	54.97 (±8.09)	58.05 (±8.50)	61.05 (±10.69)	63.26 (±12.64)	60.71 (±8.40)	$p<0.001$
BMI (kg/m²)	29	22.3 (±2.4)	21.9 (±2.8)	22.7 (±3.3)	21.1 (±2.7)	21.0 (±2.5)	22.2 (±3.3)	24.4 (±4.4)	22.7 (±2.5)	$p<0.001$
Arm span (m)	15	1.78 (±0.11)	1.74 (±0.11)	1.72 (±0.10)	1.70 (±0.08)	1.74 (±0.11)	1.74 (±0.11)	1.73 (±0.11)	1.74 (±0.09)	$p=0.004$
Sit and reach (cm)	28	10.8 (±6.7)	8.3 (±6.7)	7.3 (±7.1)	9.7 (±7.8)	6.4 (±7.8)	6.6 (±7.2)	9.5 (±7.3)	11.9 (±7.3)	$p<0.001$
Vertical jump (cm)	171	54.6 (±10.1)	50.2 (±10.2)	55.5 (±9.4)	53.2 (±12.2)	53.2 (±10.5)	49.7 (±10.7)	53.1 (±11.9)	49.4 (±7.9)	$p<0.001$
Mb throw (m)	41	4.33 (±0.85)	4.45 (±1.10)	4.30 (±0.81)	3.87 (±0.89)	4.47 (±0.92)	4.12 (± 0.90)	4.24 (±0.98)	3.51 (±0.73)	$p<0.001$
Illinois (sec)	72	15.86 (±1.13)	16.05 (±1.51)	15.88 (±1.31)	15.84 (±1.19)	15.99 (±1.54)	16.27 (±1.75)	15.86 (±1.14)	16.18 (±1.38)	$p=0.235$
5m sprint (sec)	135	1.06 (±0.11)	1.08 (±0.17)	1.02 (±0.10)	1.04 (±0.12)	1.02 (±0.12)	1.20 (±0.15)	1.00 (±0.11)	1.10 (±0.12)	$p<0.001$
20m sprint (sec)	98	3.24 (±0.30)	3.23 (±0.33)	3.14 (±0.29)	3.15 (±0.36)	3.18 (±0.32)	3.32 (±0.35)	3.02 (±0.34)	3.33 (±0.34)	$p<0.001$
Push-up (reps)	111	27.4 (±15.9)	26.9 (±14.8)	26.3 (±13.2)	21.5 (±16.0)	25.6 (±12.8)	21.2 (±14.7)	32.2 (±12.9)	21.3 (±14.1)	$p<0.001$
Sit-up (reps)	112	31.3 (±10.2)	33 (±12.6)	30.8 (±11.5)	29.5 (±9.5)	28.9 (±10.7)	30.8 (±11.1)	36.8 (±10.5)	31.3 (±8.9)	$p=0.03$
MSFT (level)	148	8.1 (±2.2)	7.8 (±3.0)	6.9 (±2.4)	7.2 (±2.4)	7.3 (±2.6)	6.4 (±2.6)	6.5 (±2.5)	7.3 (±2.3)	$p<0.001$

Table 2. Anthropometrics and performance tests by sex

Variable	No. of missing participants	Male n=491	Female n=353	*p*-value
Sex	12			
Age (years)	0	20 (±3.53)	18.76 (±3.40)	*p*<0.001
Height (m)	16	1.69 (±0.07)	1.60 (±0.06)	*p*<0.001
Leg length (m)	20	0.86 (±0.6)	0.80 (±0.05)	*p*<0.001
Body mass (kg)	20	63.62 (±9.64)	56.75 (±9.44)	*p*<0.001
BMI (kg/m²)	28	22.1 (±3.0)	22.1 (±3.3)	*p*=0.933
Arm span (m)	15	1.79 (±0.87)	1.67 (±0.75)	*p*<0.001
Sit and reach (cm)	28	6.7 (±7.4)	8.9 (±7.8)	*p*<0.001
Vertical jump (cm)	166	57.9 (±7.3)	42.3 (±7.1)	*p*<0.001
Mb throw (m)	41	4.78 (±0.69)	3.37 (±0.50)	*p*<0.001
Illinois (sec)	69	15.35 (±1.17)	17.18 (±1.46)	*p*<0.001
5m sprint (sec)	132	1.00 (±0.10)	1.16 (±0.13	*p*<0.001
20m sprint (sec)	95	3.04 (±0.17)	3.58 (±0.28)	*p*<0.001
Push-up (reps)	108	31.5 (±11.8)	12.7 (±10.5)	*p*<0.001
Sit-up (reps)	109	36.1 (±8.6)	23.6 (±9.4)	*p*<0.001
MSFT (level)	144	8.3 (±2.2)	5.1 (±1.9)	*p*<0.001

DISCUSSION

The study aimed to examine the anthropometric and performance characteristics of Papua New Guinean athletes and community dwelling persons. The study additionally aimed to determine whether there was a relationship between the examined characteristics and region of origin. The primary finding was that the birthplace of a Papua New Guinean can have a significant influence on select anthropometric and performance characteristics. Additionally, sex and age group also have significant relationships with select anthropometric and performance characteristics.

Anthropometric and performance characteristic differences by birth province

There was a significant amount of variation between the eight listed birth provinces for all tested characteristics except for measurements of leg length (*p*=0.36) and Illinois agility time (*p*=0.235) as highlighted in Table 1. Those who were born in the Central province were the tallest, heaviest and had the greatest MSFT performance and arm span. They also ranked second best for sit and reach score, vertical jump height and number of push-up repetitions completed. Participants born in Morobe recorded the best Mb throw, second greatest arm span and the quickest 5m sprint time. The last of the tier 1 birth provinces, the NCD, recorded the second largest arm span measurement out of the eight provinces.

At first glance, it may appear that of the tier 1 provinces, Central seems to be the birth province of athletes geared towards sports such as basketball due to their height, body mass, endurance and vertical jump scores (25) and Morobe may produce athletes suited to athletic throwing sports (26). However, when the percentage of male participants for Central (67.9%), Morobe (67.2%) and NCD (53.5%), are considered, it is not surprising that participants from Central and/or Morobe rank within the top two provinces for characteristics such as height, body mass, power, 5m speed and aerobic endurance. It is also worth noting, that the mean age for the tier 1 provinces, places NCD and Morobe into a younger age group (18-20 years old) than Central (21-25 years old), which ultimately may have had an effect on tested characteristics (27).

Similar findings are reported in tier 2 provinces (Table 1). For example, participants born in Sandaun province had the highest BMI, and the greatest 5m, 20m, push-up and sit-up results. Sandaun born participants also ranked second for body mass measurements. It is worth noting however that Sandaun had a high percentage of males (66.3%) and are within the 21-25 year old category (22± 3.6 years old), which is the fastest age category for participants within this study. WNB born participants re-

Table 3. Anthropometrics and performance tests by age groups

Variable	No. of missing participants	15-17 years	18-20 years	21-25 years	26-30 years	*p*-value
Sex-male/female (%)	12	47.7%/52.3%	57.6%/42.4%	72.4%/27.6%	65.2%/34.8%	$p<0.001$
Height (m)	16	1.64 (±0.08)*	1.65 (±0.07)†§	1.68 (±0.09)†‡	1.67 (±0.08)†	$p<0.001$
Leg length (m)	20	0.82 (±0.06)§||	0.83 (±0.06)§	0.85 (±0.06)†‡	0.85 (±0.06)†	$p<0.001$
Body mass (kg)	20	57.18 (±8.67)*	59.25 (±8.93)*	65.92 (±10.47)†‡	67.84 (±11.49)†‡	$p<0.001$
BMI (kg/m²)	29	21.5 (±3.0)§||	21.7 (±2.8)§||	23.2 (±3.3)†‡	24.2 (±3.5)†‡	$p<0.001$
Arm span (m)	15	1.71 (±0.10)§||	1.74 (±0.09)§	1.78 (±0.11)†‡	1.75 (±0.11)†	$p<0.001$
Sit and reach (cm)	28	5.9 (±6.7)*	8.1 (±7.8)†	8.5 (±7.6)†	10.1 (±6.9)†	$p<0.001$
Vertical jump (cm)	171	47.3 (±10.5)*	51.8 (±10.1)†	54.0 (±10.1)†	54.0 (±10.1)†	$p<0.001$
Mb throw (m)	41	3.86 (±0.83)*	4.13 (±0.91)*	4.58 (±0.89)†‡	4.66 (±0.91)†‡	$p<0.001$
Illinois (sec)	72	16.57 (±1.57)*	16.06 (±1.39)†	15.74 (±1.72)†	15.55 (±1.52)†	$p<0.001$
5m sprint (sec)	135	1.09 (±0.14)‡§	1.05 (±0.14)†	1.05 (±0.12)†	1.09 (±0.12)	$p<0.003$
20m sprint (sec)	98	3.35 (±0.34)‡§	3.22 (±0.33)†	3.17 (±0.32)†	3.29 (±0.39)	$p<0.001$
Push-up (reps)	111	17.8 (±12.5)*	23.9 (±14.5)*	29.2 (±15.3)†‡	30.2 (±12.1)†‡	$p<0.001$
Sit-up (reps)	112	27.5 (±9.3)*	30.4 (±10.7)*	34.6 (±11.0)†‡	35.7 (±10.7)†‡	$p<0.001$
MSFT (level)	148	6.0 (±2.5)*	7.0 (±2.5)†§	7.8 (±2.6)†‡	7.9 (±2.4)†	$p<0.001$

** denotes significant difference between all other age groups.*
† denotes significant difference when compared to 15-17 year old age group.
‡ denotes significant difference when compared to 18-20 year old age group.
§ denotes significant difference when compared to 21-25 year old age group
|| denotes significant difference when compared to 26-30 year old age group

Table 4. Bivariate and multivariate regression analysis for participants born in Morobe vs. participants born in NCD (baseline)

	Body mass (kg)	BMI (kg/m²)	Mb throw (m)	5m sprint (sec)	20m sprint (sec)
No. observations	536	535	528	460	491
Unadjusted (bivariate) Province Effect Morobe vs. NCD					
Constant	64.05	23.38	3.76	1.17	3.47
Morobe	-3.00*	-1.17†	0.36†	-0.08†	-0.14
R-squared	0.016	0.026	0.029	0.058	0.034
Adjusted Province Effect Morobe vs. NCD					
Constant	66.64	21.23	5.44	.927	2.615
Morobe	-3.81†	-1.18†	0.20†	-0.06†	-0.08†
Age group	3.60†	0.82†	0.22†		
Female	-5.87†		-1.33†	0.16†	0.55†
R-squared	0.224	0.079	0.646	0.368	0.620

** and † indicate p<0.05 and p<0.001 respectively.*
kg – kilograms, BMI – body mass index, Mb throw – medicine ball throw, m- metres, sec –seconds

Table 5. Bivariate and multivariate regression analysis for participants born in Central vs. participants born in NCD (baseline).

	Arm span (m)	S&R (cm)	VJ (cm)	MSFT (level)
No. observations	493	479	452	403
Unadjusted (bivariate) Province Effect Central vs NCD				
Constant	1.69	2.28	44.90	4.71
Central	0.05†	4.27†	4.82†	1.73†
R-squared	0.03	0.048	0.030	0.064
Adjusted Province Effect Central vs NCD				
Constant	1.86	-3.85	67.47	8.61
Central	0.02*	3.94†	2.44*	0.94†
Age group	0.01†	1.25†	0.95*	0.60†
Female	-0.12†	2.75†	-15.09†	-2.91†
R-squared	0.393	0.100	0.542	0.450

** and † indicate p<0.05 and p<0.001 respectively.*
m- metres, S&R – sit and reach, cm – centimetres, VJ – vertical jump, MSFT – multi-stage fitness test

corded the best mean sit and reach score and the second largest arm span and BMI results out of the eight provinces. WNB had the highest percentage of female respondents (62.3%) which may account for their superiority in flexibility tests, as previous studies have indicated that females have greater levels of flexibility throughout most of their lives (Medeiros, Araújo & Araújo, 2013). Participants from ESP recorded the highest vertical jump, second highest BMI and second quickest 5m and 20m sprint times. It is worth noting that this may also be attributed to the high percentage of male participants (73.6%) and the previously reported relationship between lower body power scores and sprint speed (29).

Whilst the above information indicates that there is a significant difference between provinces for scores of various performance and anthropometric variables, the analysis does not take into account the potential influence that sex and age may have on the tested characteristics. Due to the difference in the percentage of males and females within a province as well as the differences of mean ages, it is necessary to compare sex (Table 2) and age groups (Table 3) to tested characteristics to determine their influence on performance.

Sex differences

There are significant differences between males and females for the anthropometric measurements of height, leg length, body mass and arm span (Table 2). These findings are supported by previous research, which has shown that males are typically taller, heavier and have a greater arm span than their female counterparts (30, 31). The differences for BMI were found to be non-significant between the sexes (p=0.933), with past research showing mixed results of both significant and non- significant differences between sexes (30, 32). As BMI displays an individual's mass relative to their height, it is not unreasonable to have a non-significant difference between sexes for a BMI score while also having a significant difference for height and/or mass (30). For all performance tests, except for the sit and reach test, males performed significantly better. Similar findings have been reported previously with sexual dimorphisms thought to be the reasoning for better levels of male performance (33).

This is highlighted in other studies which have shown males reaching higher levels of performance in anaerobic power (34, 35, 36), speed (33) and aerobic endurance events (37, 38, 39). For example, Ford et al., (34) determined that female weightlifters have lesser relative strength when compared to their male counterparts, potentially due to less cross-sectional areas of muscle devoted to contractile muscle filaments. Furthermore, a study conducted on anaerobic performance of male and female elite level sprint performance by Seiler at al., (33) found that males outperformed females across running, swimming and speed skating. The authors attributed this to differences in performance, anaerobic power and physiological differences between male and female athletes. The aerobic capacity differences between males and females have been well documented in the past (37, 38, 39). A study of elite male and female badminton players found that male athletes demonstrated a significantly higher aerobic capacity than their female counterparts (39). This difference between sexes may be due to men typically having higher muscle mass and haemoglobin levels and lower body fat than women (40,41).

Muscular endurance differences between sexes seemed to be mixed in past research, with studies prior to the 1990s indicating poorer performances by females, whilst more recent studies indicating similar results between sexes (42). It is worth noting however, that the more recent studies typically use the modified push-ups on the knees rather than the traditional push-up on the toes, meaning each push-up repetition requires less strength (42). Conversely, in this study, females on average recorded better scores on the sit and reach test. This is in line with previous research, which indicated that females are more flexible than their male counterparts throughout most of their lives (28). Previous research has indicated that sex differences in flexibility scores may be due to higher muscular volume in men, which limits movement or a larger pelvic diameter in women (28, 43).

Age differences

Significant differences were found between the four age groups for sex and for all anthropometric and performance characteristics (Table 3). Post hoc analysis indicated numerous significant differences for tested characteristics across the four age groups. It appears that results for the two older age groups (21-25 years, 26-30 years) are only significantly different to the two younger age groups (15-17 years, 18-20 years), but not to each other, suggesting that there may not be a significant improvement in performance after a certain age.

As training age was not taken into account by this study, there is also a possibility that specific training interventions (e.g. strength training) undertaken may affect the relationship between age group and performance (44). The lack of experience and opportunity to engage in structured training could possibly contribute to the significant difference in anthropometric and performance characteristics of the older and younger age groups. This is an area that requires further research. Previous research has also indicated that the age in which performance peaks for various track and field athletes is 26 years old (27). However, as 26 years old is only the start of the final age group, it is possible that a larger number of participants towards the 30-year-old mark may be responsible for the decline in performance, as participants may be past their performance peak. Furthermore, as there is a well-documented difference between chronological and biological age (45), there is the possibility that athletes from PNG may mature at a faster rate, thus potentially peaking at an earlier age than their more studied western counterparts. This may explain to an extent, what appears to be plateauing of measurements between the final two age groups (21-25 years, 26-30 years) as indicated by the lack of significant differences between them. However, research into chronological age and biological maturation rates has yet to be conducted on Papua New Guineans.

The relationship between birth province, age and sex and anthropometric and performance differences

Bivariate and multivariate regression analyses were used to determine the respective effects of birth province, and the potentially confounding factors of age and sex. This was required due to the significant differences found for most anthropometric and performance results, between both sex and age groups. Furthermore, sex and age group differed significantly between the provinces, thus when testing for the association between provinces and anthropometric and performance measures, we are faced with potential confounding by age and sex. The comparisons between the respective bivariate and multivariate regression models refer to the province effect between the tier 1 provinces (Morobe vs NCD and Central vs NCD).

For example, when comparing Morobe vs. NCD (baseline); a significant bivariate effect of 0.36 is found for the performance test of Mb throw. This indicates that people within the Morobe sample threw the Mb 0.36m father than those from NCD. After controlling for confounding by age and sex, the bivariately observed 0.36m is reduced to 0.20m. Therefore, there is still a significant effect due to the differences of birth province (Morobe vs. NCD) but the bivariately observed effect of 0.36 was confounded; the adjusted effect is 0.20 (Table 3.4). Although this may seem to indicate the “true” effect of birth province, it cannot be conclusively stated, as this adjusted effect (adjusted for age and sex) may still be confounded by other variables not collected within the data set. For example, the training age of participants within the sample size of each province. As is, the “adjusted” effect within this study is still significant, but further research may be needed to determine if these are “true” inherent differences between participants born in Morobe and NCD.

The ability of the model to explain the data improves vastly after adjusting for sex and age. Again, using Mb throw as an example, the bivariate model with province effect only can explain 2.9% of the variability (=100*R-squared=100*0.029 = 2.9%). After accounting for age and sex, the resulting multivariate model can now explain 64.5% of the observed variability (Table 4). This shows that age and sex are able to explain much more of the variability in results than the province i.e. Mb throw is much more associated with age and sex than with birth province (Morobe or NCD). The difference for Mb throw distance between those born in Morobe and those born in NCD was used as an example to illustrate the effect of birth province, due to it having the highest R^2 score of all tier 1 analyses. It is apparent however, that when comparing the bivariate R^2 scores and multivariate R^2 scores across each of the analysed variables, that there is a vast improvement in the multivariate R^2 scores. This further suggests that although birth province may appear to have a significant influence on the variance of the tested characteristics (Table 4 and 5), sex and age can explain much more of the variance.

The remaining variability not accounted for by the regression analysis could be attributed to, but not limited to, independent variables not included within the regression model or cases in which the cause for the variability cannot be accounted for. It is also worth noting that while some factors (e.g. training age) could be measured to an extent and added into the model, other factors that have been shown to influence performance variables cannot (e.g. cultural differences).

The omission of other data (e.g. Mother’s place of birth) which was collected during the heritage questionnaire but not utilised during the analysis, would also need to be considered as a confounding variable.

CONCLUSION

The current study measured the anthropometric and performance characteristics of Papua New Guinean athletes and community dwelling persons. Furthermore, it determined the relationship between measured characteristics and the region of origin of its participants. It has indicated that there may be an association between the region of origin and selected anthropometric and performance characteristics of Papua New Guineans. The levels of association between anthropometric and performance characteristics and region of origin vary between each of the provinces within this study. It is worth noting, however, that other independent variables such as sex and age have a larger influence than birth province on anthropometric and performance characteristics. Furthermore, although data collected during the Heritage Questionnaire (e.g. Mother's place of birth) was omitted from analysis within this study, it would also need to be considered as a confounding variable along with sex and age.

To further identify the level of influence that birth province may have on anthropometric and performance characteristics, a larger sample size may be required, and other information not collected within this study (e.g., training age) may need to be accounted for. Due to time restraints, data collection was limited to several key locations (NCD, WNB, Morobe and Central), thus representation from some regional areas may be lacking. As this exploratory research is the first of its kind within PNG, it may have opened an avenue for further research projects to be undertaken. Ideally, future studies need to engage with those people located in remote and regional areas away from the main population centres of the country. By increasing the size of the sample and by testing in more areas to increase the variety in the heritage of the participants, a more representative and detailed analysis can be undertaken. Depending on the independent variable being investigated a sample size of 10,000 or more participants may be required.

Collectively, the findings presented in this study may be used by sporting organisations to identify sporting talent within PNG. It has also indicated that TID and TD programs can successfully be carried out in various regions within PNG.

ACKNOWLEDGMENTS

This project was made possible due to the support of the James Cook University – High-Performance Initiative and High-Performance Sport Papua New Guinea (a sub-division of the Papua New Guinea Sports Foundation). The authors thank the athletes for their participation.

REFERENCES

1. Galton, F. (2000). Classification of men according to their natural gifts hereditary genius - an inquiry into its laws and consequences (3 ed., pp. 14-37). London, England: Macmillon and Co.
2. Tucker, R., & Collins, M. (2012). What makes champions? A review of the relative contribution of genes and training to sporting success British Journal of Sports Medicine, 46(8), 555-561. doi:10.1136/bjsports-2011-090548
3. Gray, H. J., & Plucker, J. A. (2010). She's a natural: Identifying and developing athletic talent. Journal for the Education of the Gifted, 33(3), 361-368. doi:10.1177/016235321003300304
4. Baker, J., & Horton, S. (2004). A review of primary and secondary influences on sport expertise. High Ability Studies, 15(2), 211-228. doi:10.1080/1359813042000314781
5. Irving, R., & Bourne, P. (2016). The ecological model of sprinting determinants of Jamaican athletes. Austin Emergency Medicine 2(1), 1009-1016. Retrieved from http://austinpublishinggroup.com/emergency-medicine/fulltext/aem-v2-id1009.php
6. Dutton, E., & Lynn, R. (2015). Ethnic differences in success in cricket. Mankind Quarterly, 55(3), 226-241. Retrieved from https://search-proquest- com.elibrary.jcu.edu.au/docview/1674534062?accountid=16285
7. Onywera, V. O., Scott, R. A., Boit, M. K., & Pitsiladis, Y. P. (2006). Demographic characteristics of elite Kenyan endurance runners. Journal of Sports Sciences, 24(4), 415-422. doi:10.1080/02640410500189033
8. Russell, K. (1989). Athletic talent: from detection to perfection. Science Periodicals on Research and Technology in Sport Science. 9 (1): 1-6
9. Williams, A. M., & Reilly, T. (2000). Talent identification and development in soccer. Journal of Sports Sciences, 18(9), 657-667. doi:10.1080/02640410050120041
10. Vaeyens, R., Lenior, M., Williams, A. M. & Philippaerts, R. (2008). Talent identification and development programmes in sport. Sports Medicine, 38(9), 703-714. doi:10.2165/00007256-200838090-00001
11. Lidor, R., Côté, J., & Hackfort, D. (2009). ISSP Position Stand: to test or not to test? The use of physical skill tests in talent detection and in early phases of sport development. International Journal of Sport and Exercise Psychology, 7(2), 131- 146. doi:10.1080/1612197X.2009.967189

12. Pearson, D. T., Naughton, G. A., & Torode, M. (2006). Predictability of physiological testing and the role of maturation in talent identification for adolescent team sports. Journal of Science and Medicine in Sport, 9(4) 277—287. doi:10.1016/j.jsams.2006.05.020
13. Douglas, A. (2017). About TID Admissions. Retrieved from http://aspire.qa/abouttidadmissions.aspx
14. Epstein, D. (2014). Making winter sports Olympic champions out of Australian “Beach Babes”. Retrieved from https://www.scientificamerican.com/article/making-winter- sports-olympic-champions-out-of-australian-beach-babes-excerpt/
15. National Statistics Office. (2017). Population. Retrieved from https://www.nso.gov.pg/index.php/population-and-social/other-indicators
16. Klaus, D. (2003). The use of indigenous languages in early basic education in Papua New Guinea: A model for elsewhere? Language and Education, 17(2), 105-111. doi: 10.1080/09500780308666842.
17. Greenhill, S. J. (2015). TransNewGuinea.org: An online database of New Guinea languages. Public Library of Science One, 10(10). doi:10.1371/journal.pone.0141563
18. Simmons, D. (2000). Talent identification of British diving. Physiological and anthropometrical test [CD Rom].
19. Mackinnon L. T., Ritchie C. B., Hooper S. L., & Abernethy, P. J. (2003). Assessing physical fitness. Exercise Management: Concepts and Professional Practice: Human Kinetics. (3rd ed., pp. 105-137): Champaign, IL: Human Kinetics.
20. Vossen, J.F., Kraemer, J.E., Burke, D.G., & Vossen, D.P. (2000). Comparison of dynamic push-up training and plyometric push-up training on upper body power and strength. The Journal of Strength and Conditioning Research, 14 (3), 248-253.
21. Harman, E., & Garhammer, J. (2008). Administration, Scoring, and Interpretation of Selected Tests. In T. R. Baechle & R. W. Earle (Eds.), Essentials of Strength Training and Conditioning (pp. 249-306). Champaign, IL: Human Kinetics.
22. Schell, J. and Leelarthaepin, B. (1994). Physical Fitness Assessment in Exercise and Sport Science. Matraville, Australia: Leelar Biomediscience Services
23. Gabbett, T. J., Kelley, J. N., & Sheppard, J. M. (2008). Speed, change of direction speed, and reactive agility of rugby league players. The Journal of Strength and Conditioning Research, 22(1), 174-181. doi:10.1519/JSC.0b013e31815ef700
24. Léger, L. A., Mercier, D., Gadoury, C., & Lambert, J. (1988). The multistage 20 metre shuttle run test for aerobic fitness. Journal of Sports Sciences, 6(2), 93-101. doi:10.1080/02640418808729800
25. Ziv, G., Lidor, R. (2009) Physical attributes, physiological characteristics, on-court performances and nutritional strategies of female and male basketball players. Sports Medicine, 39(7), 547-68. doi: 10.2165/00007256-200939070-00003
26. Hyeyoung, K., Youngsun, L., Insik, S., Kitae, K., & Jeheon, M. (2014). Effects of 8 weeks’ specific physical training on the rotator cuff muscle strength and technique of javelin throwers. Journal of Physical Therapy Science. 26(10), 1553-1556. doi:10.1589/jpts.26.1553
27. Berthelot, G., Len, S., Hellard, P., Taffet, M., Guillaume, M., Vollmer, J… Toussaint, J. (2012). Exponential growth combined with exponential decline explains lifetime performance evolution in individual human species. Age, 34, 1000-1009. doi:10.1007/s11357-011-9274-9.
28. Medeiros O. H. B., Araújo D. S., & Araújo C. G. S. (2013). Age-related mobility loss is joint-specific: an analysis from 6,000 Flexitest results. Age, 35(6), 2399–2407. doi:10.1007/s11357-013-9525-z
29. Lockie, R. G., Jalilvand, F., Callaghan, S. J., Jeffries, M. D., & Murphy A. J. (2015). Interaction between leg muscle performance and sprint acceleration kinematics. Journal of Human Kinetics, 49(1), 65-74. doi:10.1515/hukin-2015-0109
30. Mitchell, A. C., Bowhay, A., & Pitts, J. (2011). Relationship Between Anthropometric Characteristics of Indoor Rock Climbers and Top Roped Climbing Performance. The Journal of Strength and Conditioning Research, 25, 94-95. doi:10.1097/01.JSC.0000395728.22365.7d
31. Perroni, F., Gallotta, M. C., Pisano, S., Reis V. M., Emerenziani, G. P.,Guidetti, L., & Baldari, C. (2018). Gender differences in anthropometric parameters and technical performance of youth soccer players. Sport Sciences for Health, 14, 399-405. 10.1007/s11332-018-0456-z
32. Omigbodun, O. O., Adediran, K. I., Akinyemi, J. O., Omigbodun, A. O., Adedokun, B. O., & Esan, O. (2010). Gender and Rural–Urban Differences in the Nutritional Status of in School Adolescents in South-Western Nigeria. Journal of Biosocial Science, 42(5), 653-676. doi:10.1017/S0021932010000234
33. Seiler, S., de Koning, J., & Foster, C. (2007). The fall and rise of the gender difference in elite anaerobic performance 1952–2006. Medicine and Science in Sports and Exercise, 39(30), 534-540. doi:10.1249/01.mss.0000247005.17342.2b
34. Ford, L. E., Detterline, A., Ho, K., and Cao, W. (2000). Gender and height related limits of muscle strength in world weightlifting champions. Journal of Applied Physiology 89(3), 1061-1064. doi:10.1152/jappl.2000.89.3.1061
35. Maud, P. J., and Shultz, B. B. (1986). Gender comparisons in anaerobic power and anaerobic capacity tests. British Journal of Sports Medicine. 20:51-54, 1986. doi:10.1136/bjsm.20.2.51
36. Murphy, M. M., Patton, J. F., and Frederick, F. A. (1986). Comparative anaerobic power of men and women. Aviation, Space, and Environmental Medicine. 57:636-641
37. Armstrong, N., Welsman, J. R., & Kirby, B. J. (1998). Peak oxygen uptake and maturation in 12-yr olds. Medicine and Science in Sports and Exercise, 30,165–169. doi:10.1097/00005768-199801000-00023

38. Sharp, M. A., Patton, J. F., Knapik, J. J., Hauret, K., Mello, R. P., Ito M., & Frykman P. N. (2002) Comparison of the physical fitness of men and women entering the U.S. Army: 1978-1998. Medicine and Science in Sports and Exercise, 34(2), 256-363, 2002. doi:10.1097/00005768-200202000-00026
39. Czajkowska, A., Mazurek, K., Lutosławska, G., & Żmijewski, P. (2009). Anthropometric and cardio-respiratory indices and aerobic capacity of male and female students. Biomedical Human Kinetics, 1(2009), 47-51. doi: 10.2478/v10101-009-0012-z
40. Joyner M. J. & Coyle E. F. (2008). Endurance exercise performance: The physiology of champions. The International Journal of Physiology,586, 35-44. doi: 10.1113/jphsiol.2007.133834.
41. Sandbakk O., Solli G. S. & Holmberg H. C. (2018) Sex Difference in World-Record Performance: The Influence of Sport Discipline and Competition Duration. The International Journal of Sports Physiology and Performance, 13, 2-8. doi: 10.1123/ijspp.2017-0196
42. Laughlin, N. T., & Busk, P. L. (2007). Relationships between selected muscle endurance tasks and gender. The Journal of Strength and Conditioning Research, 21(2), 400- 404. doi:10.1519/00124278-200705000-00019.
43. Cejudo A., Moreno-Alcaraz V. J., Izzo R., Robles-Palazón F.J., Sainz de Baranda P., Santonja-Medina F. (2020). Flexibility in Spanish Elite Inline Hockey Players: Profile, Sex, Tightness and Asymmetry. International Journal of Environmental Research and Public Health 17(9):3295. doi: 10.3390/ijerph17093295
44. Cristea, A., Korhonen, M. T., Häkkinen, K., Mero, A., Alén, M., Sipilä, S… Larsson, L. (2008). Effects of combined strength and sprint training on regulation of muscle contraction at the whole-muscle and single-fibre levels in elite master sprinters Scandinavian Physiological Society, 195(3), 275-289. doi: 10.1111/j.1748- 1716.2008.01843.x
45. Lloyd, R., Oliver, J., Faigenbaum, A., Myer G., & Croix, D. S. (2014). Chronological age vs. biological maturation: Implications for exercise programming in youth. The Journal of Strength and Conditioning Research. 28(5), 1454-1464. doi:10.1519/JSC.0000000000000391