Anthropometric variables and their relationship to performance and ability in male surfers.

Matthew, J. Barlow[1]

Malcolm Findlay[1]

Karen Gresty[1]

Carlton, B. Cooke[2]

Address for correspondence:

Matthew Barlow

A522 Portland Square,

Faculty of Science and Technology,

University of Plymouth.

Drake Circus,

Plymouth.

PL4 8AA.

United Kingdom.

Phone: +44(0)1752 584 734

Fax: +44(0)1752 584 710

Email: matthew.barlow@plymouth.ac.uk

[1] Faculty of Science and Technology, University of Plymouth, Drake Circus, Plymouth, United Kingdom.

[2] Carnegie Faculty of Sport and Education, Leeds Metropolitan University, Leeds, United Kingdom

Abstract

The aim of this study was to evaluate the anthropometric profiles of male surfers and investigate the relationship of these measures with performance and ability. Following institutional ethical approval 80 male surfers underwent anthropometric assessment. These surfers comprised of three sub groups of professional (*n* = 17; age: 34.12, s =3.81 years, stature: 177.28, s =6.29 cm; body mass: 78.57, s =7.17 Kg), junior national level (*n* = 16; age: 15.61, s =1.06 years, stature: 173.86, s =5.72 cm; body mass: 63.27, s =7.17 Kg) and intermediate level surfers (*n* = 47; age: 22.47, s =2.80 years, stature: 179.90, s =5.41; body mass: 77.83, s =9.43 Kg). The mean somatotype values for the different groups of surfers were found to be 2.48 - 5.00 - 1.03 for the professional surfers; 2.18 - 3.72 - 3.24 for the junior national surfers and 2.79 - 3.57 - 2.42 for the intermediate surfers. Professional surfers were significantly (P<0.01) more mesomorphic and less ectomorphic than intermediate level surfers. Significant correlations were observed between endomorphy (r=-0.399, P<0.01), Sum of 6 skinfolds (r=-0.341, P<0.05,) and Body fat % (r=-0.380, P<0.01) and the rating of ability among the intermediate group of surfers Across all participants surfer ability rating was significantly correlated with endomorphy (r=-0.366, P=<0.01), mesomorphy (r=0.442, P<0.01), sum of 6 skinfolds (r=-0.274, P<0.05), and body fat percentage (r=-0.268, P<0.05). Findings suggest that levels of adiposity and muscularity may influence the potential for progression between intermediate and professional level surfing performance.

Keywords: Body composition; sports; somatotypes; athletic performance/physiology; Muscle, skeletal; body size; body mass index.

Introduction

Surfing is an intermittent exercise that comprises bouts of high intensity exercise interspersed with periods of low intensity activity and rest. The action of surfing usually involves the surfboard being paddled out in the prone position until the surfer is behind the area of breaking waves at the “line up” or “take-off zone” Once in the “line up” the surfer waits until a suitable wave approaches, then with some powerful sprint-type arm strokes the surfer accelerates the board to match the speed of the incoming wave to allow the surfer to “catch” the wave as it pitches and begins to break. Once the surfer catches the wave, they then stand up and accelerate down the unbroken part of the wave and begin to perform a series of manoeuvres on the wave face until the wave breaks completely, the surfer falls or the wave flattens out. This process is then repeated and is the same for both free surfing (leisure) and competition (Lowdon, 1983). However contemporary competitions almost always involve a time constraint, for example 20 minutes per heat with surfers competing in an elimination process. The competition is scored by a panel of judges where points are awarded for technical difficulty and execution of manoeuvres (ASP, 2006)

Surfing as a sport has increased in popularity and the concept of earning a living as full time touring professional surfers has emerged in response to high monetary rewards offered on the World Championship Tour and in national and regional events. There is a paucity of published information relating to surfing performance in the sports science literature (Mendez-Villanueva & Bishop, 2005) with recent studies focussing on describing the demands of surfing activity (Meir, 1991; Mendez-Villanueva et al., 2006) or describing the physiological characteristics of high performance surfers (Lowdon, 1980, 1983, 1989; Lowdon & Pateman, 1980; Mendez-Villanueva et al., 2005).

There have been several studies in which the anthropometric characteristics of various athletes have been evaluated, with inferences drawn between common body types and composition with performance for specific sports (Bourgois et al., 2001; Landers et al., 2000; Reilly et al., 2000; Watts et al., 2003). Such investigations have also been performed for surfing (Felder et al., 1998; Lowdon, 1980) suggesting that surfers in the past were shorter and lighter than age-matched sporting populations, with mean male somatotype scores of 2.6 for endomorphy, 5.2 for mesomorphy and 5.2 for ectomorphy (Lowdon, 1983). Lowdon`s (1983) study was based on a sample of 76 male surfers competing at collegiate level (from various racial and national backgrounds), but no significant correlations between somatotype and finishing order were found Since Lowdon`s work (1983) the judging criteria have evolved to focus less upon length of ride and more on the performance of specific manoeuvres. It is possible that these rule changes, especially the evaluation of speed and power of manoeuvre may have affected the representative physiological characteristics of successful modern competitive surfers. Bale (2008) identified that there was a relationship between anthropometric measures of muscularity such as mesomorphy, and dynamic strength and power. Speed and power are identified as key aspects of the judging criteria relating to execution of manoeuvres and have been identified as key parameters for the performance of functional actions within surfing such as the "pop-up" (Hirvonen et al., 1987).

Given that it is based upon the application of a universally accepted set of criteria by a panel of expert judges, performance in surfing can be best measured through competition success. However the majority of surfers do not compete so measurement of their performance rests upon assessing ability to perform specific manoeuvres consecutively and the ability to deal with waves of varying height, breaking speed and “peel angle”. Hutt, Black, & Mead, (2001)developed a basic method for quantifying the surfer skill required for various types of wave conditions, which is often used as a parameter for consideration when developing artificial surfing reefs by coastal oceanographic scientists (Hutt et al., 2001) and can be used as an accepted method for assessing a range of surfing abilities. The rating system is a ten point scale that differentiates surfers by the manoeuvres they can perform, their peel angle limit and the minimum and maximum wave height in which they can successfully surf. The bottom the scale is rated as level 1 - beginner surfers, not yet able to ride the face of the wave that simply moves forward as the waves advance; a peel angle limit of 90˚ and a minimum/maximum wave height of 0.7/1.00m. Level 9 of the rating refers to “Top 44 Surfers” who are able to consecutively execute advanced manoeuvres, are not limited by peel angle and can successfully surf waves of 0.3/>4.0m of height. Level 10 was reserved for surfers that surpass current standards.

The aim of this study was to evaluate the anthropometric profiles of male surfers and to identify any anthropometrical factors which might predict performance and ability in surfing.

Methods

Following institutional ethical approval 80 male surfers participated in this study. The sample comprised of three sub-groups: Seventeen professional surfers (mean age: 34.12, s =3.81 years, stature: 177.28, s =6.29 cm; body mass: 78.57, s =7.17

Kg)were recruited at an international World Qualifying Series (WQS) 5 star event (2009). These surfers were likely to train rigorously and compete regularly in high level surfing competitions. Sixteen junior male surfers (mean age: 15.61, s =1.06 years, stature: 173.86, s =5.72 cm; body mass: 63.27, s =7.17 Kg) were also recruited from a national team who were training to attend the World Surfing Games. A further group of forty seven male intermediate surfers were recruited from the student population at the University of Plymouth (mean age: 22.47, s =2.80 years, stature: 179.90, s =5.41; body mass: 77.83, s =9.43 Kg). Informed consent for adult participants and assent for the minors was obtained before testing.

Anthropometric measures included stature (Seca 225, Birmingham UK), Body mass was measured to the nearest 0.01Kg using a digital scale (SECA 770, Birmingham UK), skinfolds (tricep, subscapular, biceps, iliac crest, supraspinale, abdominal, front thigh and medial calf) were measured using calibrated Harpenden callipers (John Bull, British Indicators, West Sussex, UK), girths (arm flexed and tensed, waist, gluteal and calf) were measured using an anthropometric tape (Lufkin W606PM, Cooper Hand Tools, Tyne & Wear, UK). Bone breadths (humerus and femur) were measured using a Holtain anthropometer (Holtain Ltd, Dyfed, UK). The measures were taken by one technician who was accredited (level 1) by the International Society for the Advancement of Kinanthropometry (ISAK). All measures were taken in accordance with the guidelines of the International Society for the Advancement of Kinanthropometry (ISAK, 2001) on the right hand side of the body regardless of handedness or stance. Measurements were taken twice and variation between measures was less than 1% for Body mass, stature, Girths and breadths with variability of less than 5% for skinfolds.

Somatotype were calculated using the Heath Carter somatotype method (Withers et al., 1987). Body mass index (BMI) was calculated by dividing the body mass in kilograms by the square of stature (m). Sum of eight skinfolds and sum of six skinfolds (excluding bicep and illiac crest) were calculated according to Norton & Olds (2004). Body fat percentage values were calculated using the equation of Yuhasz (1974).

Means and standard deviations were calculated for each of the anthropometric variables. As the ranking data (dependant variable) is of neither interval or ratio level, Spearman`s rank correlation coefficients were calculated to establish the relationship between the different anthropometric variables and the ranking of the professional surfers. The same analysis was used to determine the relationship between the anthropometric variables and the final British ranking at the end of season for the junior British surfers. The Hutt et al (2001) rating of surfer was used to quantify each surfer`s surfing skill and was correlated with each surfer`s anthropometric variables by means of Spearman`s rank correlation coefficient method for the intermediate surfers. In order to determine the relationship of anthropometric variables to surfing ability across all three groups, the data set was combined based on ability; with the professional surfers (Hutt rating 8) being ranked in order, above the top amateur junior surfers (Hutt rating 7) who were ranked in order, above the intermediate surfers who were ranked only on their surfer skill rating. This created 36 levels of ability ranging from level 3 intermediate surfers who are able to successfully ride laterally along the wave and generate speed upon the face of the wave; to the top rankedlevel 8 Professional surfer (whom are all able to consecutively execute advanced manoeuvres).

The analysis of covariance (ANCOVA) was used to test for significant (P<0.05 or P<0.01) differences between the groups (junior, professional and intermediate) of surfers. Age was considered as a covariate as this factor could possibly confound the relationships of the physiological variables across the groups of differently aged surfers. Correlations were normalised so that a positive correlation would indicate an increase in performance with increasing value of the independent variable. All statistical analyses were performed using SPSS version 17.

Results

The descriptive statistics for the anthropometric variables of the different groups of surfers are presented in Table 1. This followed by the somatoplots for the three surfer groups, which are shown in Figure 1.

Table 1 gives the mean and s values for the anthropometric characteristics of the professional, junior and intermediate surfers. Significant differences (P<0.05) were observed between the professional and junior surfers for body mass, illiac crest skinfold, abdominal skinfold, relaxed arm girth, calf girth, mesomorphy, Ectomorphy, BMI and body fat percentage.

Significant differences (P<0.05) were also observed between junior and intermediate surfers for stature, iliac crest skinfold, supraspinale skinfold, calf girth, endomorphy, ectomorphy, BMI, sum of six skinfolds and body fat percentage. Further significant differences (*P*<0.05) were found between the professional and intermediate surfers for supraspinale skinfold, humerus breadth, femur breadth, mesomorphy and ectomorphy.

Table 2 gives the correlations (Spearman`s rank) for the calculated anthropometric indices and the performance measure for each of the groups and as a combined data set. Significant correlations (*P*<0.05) were found within the intermediate group between Hutt scale ranking and Endomorphy, sum of six skinfolds and body fat percentage. Significant correlations were found for the combined data (across all groups) between overall ranking and endomorphy, mesomorphy, ectomorphy and body fat percentage.

Discussion

The key findings of this study suggest that there were significant differences between the individual groups of surfers for various anthropometric measures and that each group can be described with a specific somatotype; professional surfers 1.48 – 5.00 – 1.03, junior surfers 2.18 – 3.72 – 3.24 and intermediate surfers 2.79 -3.57 – 2.42. Furthermore, it has been identified that mesomorphy is positively correlated with level of ability whereas endomorphy and increased levels of body fat are inversely related to level of ability in surfing.

The measures of stature and body mass suggest that changes may have occurred since since Lowdon`s(1980) study with the current professional surfers being both taller and heavier.; with professional surfers . Body mass values derived from the present study also higher than those reported for European Level Surfers (ELS) by Mendez-Villanueva (2005). Body fat percentage values in the current study are similar to those presented by Lowdon and Pateman (1980) for international surfers. Sum of six skinfolds values were much higher for the professional surfers than those reported for ELS (Mendez-Villanueva et al., 2005). Notably, the mean value for flexed arm girth among the professional surfers in this study was higher than those presented by Lowdon (1980).

Surfing performance has been found to be highly variable in nature (Mendez-Villanueva et al., 2010) due largely to unstable environmental conditions such as wave size, wind conditions and tide that will vary from competition to competition and heat to heat; indeed these factors will vary over the course of a single heat having an impact upon surfing performance. These environmental factors coupled with subjective surfing performance assessment of what is a strongly skill focussed sport make it difficult to identify physiological factors that are related to performance. Lowdon (1980) was unable to find any significant correlations between order of finish (rank) in the Bells Beach Surfing Championships of 1978 and the anthropometric features of the participants. Similarly the results for the professional surfers in the current study produced no significant correlations between the anthropometric variables and the rank of the surfers within the group.

When the anthropometric data for junior surfers were correlated to their current Great Britain national points standing at the close of the 2008 season; an interesting finding was that insignificant but positive correlations were found between endomorphy, sum of six skinfolds and body fat percentage which may suggest that higher levels of adiposity are associated with better surfing performances among junior surfers. At first, this result was surprising, but in view of the homogeneity of the national junior surfer group, it is not. The levels of body fat percentage are relatively low and do not vary greatly. Both Felder et al (1998) and Lowdon (1980) also suggested that surfers may benefit from a comparatively higher level of body fat due to the insulation needed in the cold water, although this advantage will be negated by the use of wetsuits. Furthermore (Felder et al., 1998) noted that surfers generally make use of poor nutritional strategies which may lead to a state of energy deficit during periods of increased surfing frequency and extended surfing sessions (up to 4-5 hours) (Mendez-Villanueva & Bishop, 2005). In these periods fat deposits may act as a useful source of energy (Ranallo & Rhodes, 1998). Therefore, surfers in the junior group who are at the lower end of the body fat percentage range (6.62%-10.79%) may suffer reduced ability to perform activity and manoeuvres due to limited availability of energy fat sources during extensive surfing sessions. Surfers generally do not seek nourishment or fluid replenishment during a surfing session and free fatty acids may compensate for lower glycogen levels towards the end of the session (Bangsbo et al., 2007). The junior surfers exhibited lower levels of body fat than comparative groups of junior volleyball players (Duncan et al., 2006) and active children and youths (Watts et al., 2003) but higher than junior competitive sport rock-climbers (Watts et al., 2003). The sum of six skinfold values for the junior national level surfers were similar to the values reported by Mendez-Villanueva et al *(2005)* for European Level Surfers. It is accepted that the junior surfers in the current study are considerably younger than the participants of Mendez-Villanueva et al *(2005)* but to date there exists no body composition data for comparatively aged surfers and it is interesting to see similar values within the competitive surfers regardless of age.

The range of ability in the group of intermediate surfers ranged from level 3 - surfers able to ride laterally along the wave face and have developed the ability to generate speed by ‘pumping’ on the wave face; to level 6 – surfers who are able to execute standard manoeuvres such as bottom turns, top turns and cut-backs consecutively and occasionally perform advanced manoeuvres such as ‘floaters’ and barrel riding. When analysing the intermediate surfers, Spearman`s rank correlations were performed between the calculated anthropometric indices and the rating of surfer skill. Significant relationships were found for endomorphy, sum of six skinfolds and body fat percentage. These results suggest that lower levels of adiposity are related to higher surfing ability levels among the intermediate group of surfers. This group displayed the highest variability for body fat percentage when compared to the other groups which may be related to the variability in ability.

An analysis of covariance (ANCOVA) was used to compare the anthropometric results between the different groups of surfers with age as a covariate. Significant differences of physical measures between the groups are likely to relate to maturational differences such as the variables of body mass, stature, bicep girth, calf girth and bone breadths but the mesomorphy score for the professional surfers was significantly higher than the values reported for the intermediate surfers suggesting this may be related to performance. There may be some maturational effects within the data with the relatively lower levels of body fat percentage in the junior group perhaps being representative of adipose variations around the time of growth spurts (Norton & Olds, 2004). The significant differences in mesomorphy between groups did not follow the pattern that would be expected of a maturational effect and there was no correlation between age and mesomorphy (Bale et al., 1992).

The data from all three groups were combined and the calculated anthropometric variables were correlated with the surfer skill rating and individual rank within the groups (Hutt et al., 2001). Significant correlations were found for endomorphy , mesomorphy, , sum of six skinfolds and body fat percentage. This data suggest that higher levels of muscularity and lower levels of adiposity are associated with improvement in surfing skill along the continuum of ability from intermediate to professional. In considering maturational effects and there was no correlation between age and skill rating (Hutt et al, 2001) or group. However a significant relationship was found between age and overall combined ranking ($r= 0.299$, $P<0.05$). This result is interesting as all of the junior surfers were ranked above all of the older intermediate surfers and it may be that this is an artefact induced by the greater mean age of the professional surfers who took part in this study. This is in agreement with Mendez Villanueva & Bishop (2005) who found professional surfers to be consistently over the age of 25, perhaps as a result of the time taken to master the skills required and the strategy of competition with potentential financial rewards delaying retirement. Indeed Kelly Slater the current 11 times world surfing champion is one of the oldest (39 years of age) and the highest earning surfers (over $3 million) on the professional tour(ASP, 2011).

Conclusions

It appears that different factors may be influential, dependent on the level of participation. Within the ranks of Professional surfers it would seem those exhibiting maximised muscularity whilst maintaining a relative low BMI are favoured. The results of the study also indicate that Junior National surfers need to be mindful of maintaining appropriate levels of body fat but not allowing these to fall too low; and intermediate level surfers need to manage their weight to maintain relatively low levels of body fat to underpin improvement in performance. Overall the study concludes that levels of adiposity and muscularity are factors that may influence surfing ability and the progression from intermediate to professional level surfing performance.

Practical implications

- A mesomorphic somatotype / upper body muscularity should be encouraged to allow surfers to achieve high levels of performance.
- Coaches should consider maintaining sufficient levels of body fat for junior competitive surfers.
- Intermediate and professional surfers need to manage their weight to maintain relatively low levels of adipose tissue.

Acknowledgements

The authors wish to thank the British Surfing Association (BSA) and the British Professional Surfing Association (BPSA) for facilitating access to participants.

References

ASP. (2006). Judging Criteria Retrieved 1st November 2006, from http://www.aspworldtour.com/

ASP. (2011). ASP Men`s world ranking Retrieved 7/11/2011, from http://www.aspworldtour.com/rankings/asp-mens-world-ranking/

Bale, P., Mayhew, J. L., Piper, F. C., Ball, T. E., & Willman, M. K. (1992). Biological and performance variables in relation to age in male and female adolescent athletes. *J Sports Med Phys Fitness, 32*(2), 142-148.

Bangsbo, J., Iaia, F. M., & Krustrup, P. (2007). Metabolic response and fatigue in soccer. *Int J Sports Physiol Perform, 2*(2), 111-127.

Bourgois, J., Claessens, A. L., Janssens, M., Van Renterghem, B., Loos, R., Thomis, M., et al. (2001). Anthropometric characteristics of elite female junior rowers. *J Sports Sci, 19*(3), 195-202.

Duncan, M. J., Woodfield, L., & al-Nakeeb, Y. (2006). Anthropometric and physiological characteristics of junior elite volleyball players. *Br J Sports Med, 40*(7), 649-651; discussion 651. doi: 40/7/649 [pii]

10.1136/bjsm.2005.021998

Felder, J. M., Burke, L. M., Lowdon, B. J., Cameron-Smith, D., & Collier, G. R. (1998). Nutritional practices of elite female surfers during training and competition. *Int J Sport Nutr, 8*(1), 36-48.

Hirvonen, J., Rehunen, S., Rusko, H., & Harkonen, M. (1987). Breakdown of high-energy phosphate compounds and lactate accumulation during short supramaximal exercise. *Eur J Appl Physiol Occup Physiol, 56*(3), 253-259.

Hutt, J. A., Black, K. P., & Mead, S. T. (2001). Classification of surf breaks in relation to surfing skill. *Journal of coastal research, 29*(Special issue), 66-81.

Iaia, F. M., Thomassen, M., Kolding, H., Gunnarsson, T., Wendell, J., Rostgaard, T., et al. (2008). Reduced volume but increased training intensity elevates muscle Na+-K+ pump alpha1-subunit and NHE1 expression as well as short-term work capacity in humans. *Am J Physiol Regul Integr Comp Physiol, 294*(3), R966-974. doi: 00666.2007 [pii]

10.1152/ajpregu.00666.2007

ISAK. (2001). *International standards for anthropometric assessment*: International Society for the Advancement of Kinanthropometry.

Landers, G. J., Blanksby, B. A., Ackland, T. R., & Smith, D. (2000). Morphology and performance of world championship triathletes. *Ann Hum Biol, 27*(4), 387-400.

Lowdon, B. J. (1980). The Somatotype of International Surfbard Riders. *australian Journal of Sports Medicine, 12*, 34-39.

Lowdon, B. J. (1983). Fitness Requirments for Surfing. *Sports Coach, 6*, 35-38.

Lowdon, B. J. (1989). Specificity of Aerobic fitness testing of surfers. *The Australian Journal of science and medicine in sport, 21*(4), 7-10.

Lowdon, B. J., & Pateman, N. (1980). Physiological parameters of international surfers. *australian Journal of Sports Medicine, 12*, 30-33.

Meir, R. A. L., B.J.; Davie, A.J. (1991). Heart rates and estimated energy expenditure during recreational surfing. *australian Journal of Science and Medicine in Sport, 23*(3), 70-74.

Mendez-Villanueva, A., & Bishop, D. (2005). Physiological aspects of surfboard riding performance. *Sports Med, 35*(1), 55-70.

Mendez-Villanueva, A., Bishop, D., & Hamer, P. (2006). Activity profile of world-class professional surfers during competition: a case study. *J Strength Cond Res, 20*(3), 477-482.
Mendez-Villanueva, A., Mujika, I., & Bishop, D. (2010). Variabilty of competitive perfromance assessment of elite surfboard riders. *Journal of Strength and Conditioning Research, 24*(1), 135-139.
Mendez-Villanueva, A., Perez-Landaluce, J., Bishop, D., Fernandez-Garcia, B., Ortolano, R., Leibar, X., et al. (2005). Upper body aerobic fitness comparison between two groups of competitive surfboard riders. *J Sci Med Sport, 8*(1), 43-51.
Norton, K., & Olds, T. (2004). *Anthropometrica*. Sydney University of New South Wales Press.
Ranallo, R. F., & Rhodes, E. C. (1998). Lipid metabolism during exercise. *Sports Med, 26*(1), 29-42.
Reilly, T., Bangsbo, J., & Franks, A. (2000). Anthropometric and physiological predispositions for elite soccer. *J Sports Sci, 18*(9), 669-683.
Watts, P. B., Joubert, L. M., Lish, A. K., Mast, J. D., & Wilkins, B. (2003). Anthropometry of young competitive sport rock climbers. *Br J Sports Med, 37*(5), 420-424.
Withers, R. T., Norton, K. I., Craig, N. P., Hartland, M. C., & Venables, W. (1987). The relative body fat and anthropometric prediction of body density of South Australian females aged 17-35 years. *Eur J Appl Physiol Occup Physiol, 56*(2), 181-190.
Yuhasz, M. S. (1974). *Physical fitness manual*. London Onatario: University of Western Ontario.

Table 1. Skill and anthropometric variables of professional, national junior and intermediate level surfers (mean ± s).

Measure	Professional (*n*= 17)	Junior (*n*= 16)	Intermediate (*n*= 47)
Body mass (kg)	78.57 ± 7.17 **	63.27 ± 7.17 ††	77.83 ± 9.43
Stature (cm)	177.28 ± 6.29	173.86 ± 5.72	179.90 ± 5.41**
Triceps skinfold (mm)	8.69 ± 4.25	7.72 ± 2.38	8.93 ± 2.91
Subscapular skinfold (mm)	10.88 ± 4.46	8.13 ± 2.63	10.59 ± 4.44
Biceps skinfold (mm)	3.84 ± 1.18	4.69 ± 0.77	5.10 ± 2.54
Iliac Crest skinfold (mm)	14.41 ± 6.75	8.78 ±3.95	13.64 ± 5.55
Supraspinale skinfold (mm)	7.03 ± 3.53	6.78 ± 2.22	10.05 ± 4.57*†
Abdominal skinfold (mm)	14.71 ± 5.20*	10.48 ± 4.42	14.56 ± 6.39**
Front Thigh skinfold (mm)	13.27 ± 7.74	11.03 ± 2.90	11.88 ± 3.50
Medial Calf skinfold (mm)	9.71 ±5.67	8.24 ± 2.15	8.38 ± 2.26
Relaxed arm girth (cm)	33.36 ± 2.23**	27.71 ± 4.24†	31.89 ± 2.41**
Flexed arm girth (cm)	34.02 ± 2.36	30.46 ± 2.45	34.53 ± 2.51

Waist girth (cm)	83.11 ± 3.91	73.01 ± 3.26	81.23 ± 5.69
Gluteal girth (cm)	101.04 ± 4.63	85.03 ± 9.57	98.59 ± 5.42
Calf girth (cm)	37.05 ± 1.27**	34.13 ± 2.59††	36.82 ± 2.64**
Humerus breadth (cm)	6.87 ± 0.37	6.70 ± 0.48	6.40 ± 0.53 ††
Femur breadth (cm)	9.58 ± 0.44	9.19 ± 0.43	8.96 ± 0.72††
Endomorphy	2.48 ± 1.12	2.18 ± 0.71	2.79 ± 1.03
Mesomorphy	5.00 ± 1.02	3.72 ± 0.88††	3.57 ± 0.90††
Ectomorphy	1.03 ± 1.06	3.24 ± 1.37	2.42 ± 1.08††
Body Mass Index (BMI)	24.99 ± 1.61**	20.91 ± 1.93††	23.90 ± 2.49**
Sum of 6 skinfolds (mm)	64.29 ± 28.14	50.74 ± 14.33	64.36 ± 20.22
body fat percentage	11.28 ± 4.20*	8.41 ± 2.37 †	10.87 ± 21.49*

*significantly different to junior surfers *P*<0.05, **significantly different to junior surfers *P*<0.01, † significantly different to professional surfers *P*<0.05, †† significantly different to professional surfers *P*<0.01.

Table 2. Calculated anthropometric indices Spearman`s rank correlation with performance measure (professional surfers competition ranking, junior surfers national ranking, intermediate surfers Hutt rating, combined data set related to sample ranking).

	Professional (n=17)	Junior (n=16)	Intermediate (n=47)	Combined (n=80)
Endomorphy	r=- 0.199	r=0.357	r=-0.399**	r=- 0.366**
Mesomorphy	r=- 0.094	r=-0.061	r=- 0.028	r=0.442**
Ectomorphy	r= - 0.641	r=- 0.018	r=0.239	r=- 0.204
Body Mass Index (BMI)	r=- 0.015	r=- 0.011	r=- 0.252	r=- 0.088
Sum of 6 skinfolds (mm)	r=- 0.270	r=0.227	r=- 0.341*	r=- 0.274*
body fat %	r=- 0.187	r=0.314	r=- 0.380**	r=- 0.268*

*correlation significant at P<0.05, **correlation significant at P<0.01

Figure Legends

Figure 1. Somatotype distribution of the surfers; intermediate surfers (*n* = 47), mean somatotype = 2.79 - 3.57 – 2.42; junior surfers (*n* = 16), mean somatotype = 2.18 - 3.72 - 3.24; Professional surfers (*n* = 17), mean somatotype = 2.48 - 5.00 - 1.03