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Peer Review

ANTHROPOMETRIC CHARACTERISTICS, UPPER-BODY STRENGTH, AND SPRINT PADDLING PERFORMANCE IN COMPETITIVE SURFERS

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ABSTRACT

The present study examined the potential differences in anthropometric characteristics, upper-body strength, and sprint paddling performance between youth and senior competitive surfers. Twenty competitive male surfers (19.1±6.8 years, 168.2±11.3 cm, 61.7±13.6 kg) were assessed for stature, mass, arm-span, ∑ 7 site skinfold thickness, Lean-Mass Ratio (LMR, ∑ 7 site skinfold/kg body-mass), pronated pull-up 1 repetition maximum (1 RM) and sprint paddling performance from a stationary start to 15 m. Independent t-tests were used to compare potential differences between youth (n:10) and senior group (n:10) of competitive surfers, with Cohen's Effect Size (*d*) applied to reflect the magnitude of any differences observed. Senior surfers were not different from youth surfers for ∑ 7 site skinfold thickness, yet had greater stature ($p<0.001$, d=2.7) and mass ($p<0.001$, d=2.8). Consequently, the composite lean mass ratio (body-mass/∑ 7 site skinfold thickness, LMR) was greater ($p=0.001$, d=1.7) in senior competitive surfers. The senior surfers were faster in the 0-15 m sprint paddle test ($p<0.001$, d=2.9), possessed higher peak paddling velocity ($p<0.001$, d=2.3) and had greater absolute 1 RM pull-up strength ($p<0.001$, d=2.8) and 1 RM pull-up strength relative to body-mass (1 RM pull-up mass/subjects body-mass) ($p<0.001$, d=2.2). The results of this study suggest that practitioners working with competitive surfers should consider the importance of sprint paddle performance in surfers, and the need to optimize lean mass and relative strength, as these factors appear to distinguish between surfers of higher and lower athletic development and competitive level in the surfing population.

Keywords - surf, surfing, power, testing.

INTRODUCTION

Competitive surfing heats, which generally last 20-30 minutes, are structured such that successful surfers from each round of competitive heats progress through the competition until quarter, semi, and final rounds are completed, and placing determined. Depending on the surf conditions, the contest format, the competitive level of the event, and other factors, surfers may be involved in several heats in a single day or days (with only 30 min to a few hours between heats), or have an entire contest involving up to 6 heats spread over a 14 day time period. Depending on the competition format, 2-4 surfers are placed in each heat, with 1 or 2 surfers advancing, and the losing surfers being eliminated. Competitive success is determined by judging criteria that rewards the performance of critical manoeuvres. To this end, the surfers must be strategic in wave selection, as the surfers' success is judged by their ability to obtain and ride the best waves during a competition, and ride them better than their opposition.

Surfing is a highly skilled performance, and it is believed that surfers require several important athletic qualities including strength and power, mobility, balance and coordination, and anaerobic and aerobic abilities (6). Previous examinations have demonstrated that short-duration paddle power (3) and upper-body endurance performance (8) may be valid performance discriminators between higher and lower performing competitive surfers. However, at present, there is a dearth of descriptive studies examining the physical qualities of surfers. With few examinations involving competitive surfers, it is difficult for practitioners to develop a sound basis of rationale for decision-making on training priorities with surfing athletes.

Although previous manuscripts have provided a descriptive construct of the basic anthropometric characteristics of specific populations of surfers (5-8), no studies to date have examined anthropometric, strength, and sprint-paddling characteristics of younger and older competitive surfers, nor trainable physical factors such as strength and sprint paddling performance. Comparative analysis of developing (youth) and senior (adult) competitive surfers, can inform decision-making on the developmental and training requirements of competitive surfers. As such, the present study aimed to evaluate the anthropometry, upper-body pulling (pronated pull-up) strength, and sprint paddling kinematics of competitive surfers.

METHODS

Subjects

Ten senior competitive male surfers (23.9±6.8 years, 177.0±6.5 cm, 72.2±2.4 kg) and 10 youth competitive male surfers (14.3±1.4 years, 159.5±7.8 cm, 51.2±9.6 kg) participated in this study. At the time of the study, the adult subjects had competed, as a minimum standard, in domestic 'open' competition, with the majority of subjects having competed in the Association of Surfing Professionals World Qualifying Series events. All of the senior competitive male surfers engaged in activity in addition to their surfing, but this varied in nature from formal and coached strength-conditioning and Olympic lifting (n:6), unstructured and self-directed strength and conditioning (n: 3), and recreational soccer (n:1). The youth surfers had competed in scholastic surfing competitions and domestic age-group competitions, and were a part of a formally coached high-school surfing squad, that included basic introductory strength and conditioning activities (warm-up, stretching, and conditioning/'cross-training') in a regular but infrequent (~1-2 sessions conducted/week in addition to surf sessions).

All subjects received a clear explanation of the study, including the risks and benefits of participation and if following this explanation their decision was to not be included in the analysis it did not adversely affect any current or future competitive or team opportunities. All included subject's provided written informed consent for testing and data analysis. Approval for this investigation was granted from the Institutional Human Ethics Committee, and the study conformed to the Declaration of Helsinki for medical research involving human subjects.

Procedures

For the testing of both the youth and senior groups, the subject group was divided into equal halves of 5 subjects. One group performed their sprint-paddle testing, whilst the other group undertook the anthropometry and strength assessment. At the conclusion of this and following a 10 minute break, the groups were then alternated so that all testing could be completed for all subjects.

Anthropometry

All subjects were assessed for height, mass, standing reach, arm-span, and the sum of 7 skin-folds. The sum of 7 skin-folds was determined following measurement of the triceps, sub scapulae, biceps, supra-spinale, abdominal, quadriceps, and calf skin-fold using a Harpenden skinfold calliper (British Indicator, UK). A composite ratio of body-mass divided by the sum of 7 skin-folds was then determined to reflect the amount of mass that is made up of lean tissue, termed the Lean Mass Ratio (LMR)(12). All tests were conducted by a single researcher certified by the International Society for the Advancement of Kinanthropometry (ISAK). The percentage typical error (%TE) for stature, mass, and standing reach, were 1.5%, 1.2%, and 2.0% respectively, whilst the %TE for the skin-fold assessment was 2.2%.

Sprint Paddling

Sprint paddle testing was conducted in an outdoor 50 m swimming pool. This allowed for easy outline of distances for the subjects, control for the potential effect of tides and currents experienced in most local waterways, and provided for professional supervision by lifeguards and elimination of potential dangers from marine creatures.

Subjects performed a progressive warm-up 200 m of low-intensity paddling, followed by a specific sprint paddling warm-up of 4 x 15 m sprint paddling efforts at 60, 70, 80, and 90 % volitional effort on ~2 minute time intervals. After 3-4 minutes rest, the subjects then performed 2 maximal effort sprint-paddling time-trials (i.e. 2 x 15 m) to determine maximum sprint paddling performance. The sprint paddle efforts were initiated from a stationary, prone lying position. Subjects used their own competitive surfboard for average conditions (also called an 'all-rounder' or 'normal' competition board). This was considered appropriate so that each subject was familiar with the dimensions, trim, and buoyancy characteristics of the board, and therefore able to provide context-valid data that was representative of their performance in competition.

Using a purpose-built horizontal position transducer (I-REX, Southport, Australia) attached to the back of each subjects shorts, kinematic data was obtained and stored for analysis on a personal computer. The position transducer recorded a time-stamp for each 0.02 m of displacement, thereby allowing for determination of sprint time from the start to 5m, 10m, and 15m, and by differentiation to determine peak sprint paddle velocity (4). The %TE for 5m, 10m, 15m, and peak velocity were 4.4%, 2.6%, 2.1%, and 2.2% respectively,

Upper-Body Strength

Subjects were assessed on their 1 repetition maximum (1RM) for the Pronated Pull-Up, which is the value of the subject's body-mass and any additional load lifted. This value can also be represented relative to body-mass as 1RM (kg)/body-mass (kg). Prior to the strength testing, subjects performed 3 sets of a 30 second medicine ball circuit emphasizing upper-body and trunk activity, with 1 minute rest between each medicine ball set. Four to five sub-maximal preparatory sets (2-4 reps), separated by 2-3 minutes rest, were used to graduate the subjects' resistance load (using 2.5 kg – 5 kg progressions depending on the subject's perceived ability to lift additional loads) prior to the 1 RM trials. Subjects' were lifted to the final (i.e. upper) position with arms flexed fully at the elbow and the elbows in line with the scapulae such that the arms were flexed at the shoulder and scapulae adducted. The subjects then performed the initial eccentric action to a complete 'hang' position, then the concentric action to return to the start position. This technique is appropriate for performing 1 RM testing in the Pull-Up as it allows for an eccentric action to precede the concentric action, as per most other 1 RM tests. This sequence is similar to that typically performed in sporting settings, and due to the contractile and neurogenic enhancements of an eccentric-concentric sequence, likely yields more relevant and superior results (1, 2, 10, 13).

Statistical Analyses

Independent t-tests were used to assess differences between the youth and senior groups for anthropometric, strength, and sprint paddling characteristics, with Cohen's effect size (*d)* applied to determine the magnitude of any differences. For all tests, minimum significance was considered to be achieved when $p<0.05$.

RESULTS

Senior surfers were not different from youth surfers for ∑ 7 site skinfold thickness, yet had greater stature (p<0.001, *d*=2.7) and mass (p<0.001, *d*=2.8). Consequently, the composite lean mass ratio (body-mass/∑ 7 site skinfold thickness, LMR) was greater (p=0.001, *d*=1.7) in senior competitive surfers (Table 1). The senior surfers were faster in the sprint paddle test across all 5 m intervals (p<0.001, *d*=2.1-2.9), and possessed higher peak paddling velocity (p<0.001, *d*=2.3) (Table 2). The senior subjects had greater absolute 1 RM pull-up strength (p<0.001, *d*=2.8) and 1 RM pull-up strength relative to body-mass (1 RM pull-up mass/subjects body-mass) (p<0.001, *d*=2.2) (Figure 1).

Table 1 - Anthropometrical comparison (mean±SD) of Youth (n:10) and Senior (n:10) competitive surfers.

	Youth	Senior	P-value	Effect Size
Stature (cm)	159.5±7.8	177.0±6.5	<0.001	2.7
Mass (kg)	51.2±9.6	72.2±7.4	<0.001	2.8
Arm-Span (cm)	164.9±7.4	185.8±6.7	<0.001	3.1
∑7 skinfolds (mm)	69.9±25.7	64.4±20.7	0.60	0.3
LMR	0.8±0.2	1.2±0.3	0.001	1.7

Table 2 - Sprint paddle performance comparison (mean±SD) of Youth (n:10) and Senior (n:10) competitive surfers.

Sprint Paddle Test	Youth	Senior	P-value	Effect Size
0-5 m (s)	4.12±0.25	3.68±0.21	<0.001	2.1
0-10 m (s)	7.35±0.40	6.60±0.28	<0.001	2.7
0-15 m (s)	10.6±0.60	9.52±0.37	<0.001	2.9
Peak Velocity (m/s)	1.60±0.09	1.78±0.08	<0.001	2.3

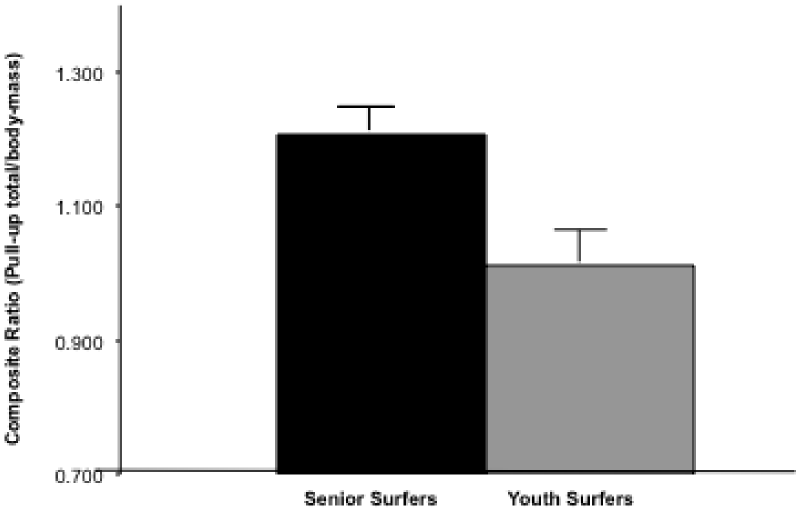

Figure 1 - Relative Pull-up Strength (1 RM Pronated Pull-up total/body-mass) comparison of Youth (n:10) and Senior (n:10) competitive surfers.
Observed difference <0.001

DISCUSSION

The purpose of this study was to evaluate the potential differences in anthropometric characteristics, upper-body pulling (pronated pull-up) strength, and sprint paddle kinematics between two groups of competitive surfers of differing age. The results of this study provide novel data on the characteristics of developing and senior surfers and provide evidence of the importance of developing sprint paddling ability and relative upper-body strength.

As can be expected, the senior group of surfers were taller and heavier than the junior group of surfers. Senior surfers did not have higher sum of 7 skinfolds, resulting in a considerably larger LMR for senior surfers (Table 1). This finding stands to reason, as the senior surfers are likely to have a higher LMR simply due to normal maturation. However, the finding does suggest that attention should be paid to lean mass: fat mass ratios in surfers, as this would appear to be an important consideration. Surfboard paddling and surfboard riding involves control and locomotion of the surfer and his or her board, and therefore performance is related to relative strength and power in these tasks. In fact, based on experience in other sports (9) and on unpublished data on elite surfers, the current authors' would consider the average LMR results of 1.2 to be low, and that higher expectations for LMR could be set (i.e. lower fat mass relative to lean mass). The strength and conditioning of surfers should aim to develop 'functional mass' levels in surfers, with the achievement of relative strength and leanness likely a considerable issue.

Both surfboard paddling and strength-training movements such as pronated, supinated, and varying pull-up variations can be described as closed-kinetic-chain movements. As demonstrated by recent data demonstrating a high correlation between sprint paddling and surfers and pronated pull up strength (11), the commonality between the movements in terms of kinetic-chain nature (i.e. anchoring with the arm and pulling oneself over the water surface and pulling oneself towards a bar), and major musculature involved in the movements, suggest that improving strength in these movements may yield positive sprint paddling results in surfers.

Despite the findings of the present study, and the basic rationale of the performance benefits of strength and conditioning to surfing performance, it is not entirely common for competitive surfers to engage in comprehensive strength and conditioning programs. Without specific guidance from strength and conditioning coaches and sport-scientists, it could be stated that competitive surfers would tend to typically engage in mobility sessions (stretching, yoga), simple reactive balance training (i.e. proprioceptive overload), and possibly endurance training. Although these training methods quite likely have their place in the preparation of surfers, they do not develop strength specifically, a consideration that is in part supported by our findings and of course critical thinking about the demands involved in the sport such as paddling and explosive whole-body manoeuvres.

Many questionable practises, and beliefs with little or no evidence-base, pervade in the surfing fraternity in regards to appropriate training methods. For example, anecdotally it is commonplace to hear that resistance training in surfers is inappropriate as 'surfers don't need to be big', and there exists a belief that any strength training might lead to immediate and profound performance-restricting limitations in mobility. Of course, the informed practitioner understands that strength training could provide considerable injury resiliency and performance benefits to the surfing athlete. Furthermore, radical gains in size could not take place with a moderate volume of strength training and a normal diet in the surfing athlete, particularly considering the volume of extensive training (surfing) that competitors undertake (i.e. 12-25 hours/week), which would prevent large mass gains even if the program was designed for that purpose. By contrast, proprioceptive overload training (i.e. unstable surface) is commonplace with the intention to improve sensorimotor ability, yet typically, little attention is paid to whole-system sensorimotor training (i.e. also including visual and vestibular demands in a 'proactive balance' rather than 'reactive balance' demand), nor does it appear that the potential role of neural control and neurogenic and myogenic strength limitations are understood. For the strength and conditioning coach, the pervasive conceptions (and possible misconceptions) present an exciting challenge when working with surfing athletes, as the training culture is not well developed, nor has the sport received considerable support in regards to physical preparation.

Further research within surfing is needed to help the strength and conditioning community demonstrate the role and inter-play of multiple physical components on performance factors related to surfing. In specific reference to the findings in the present study, a training study examining the effect of implementing an upper-body strength program (aimed to improve relative upper-body pull-up strength) on sprint paddling ability, is a logical progression, as the current findings to not demonstrate a cause and effect relationship between the superior relative strength and the faster sprint paddling performance in our subject group.

PRACTICAL APPLICATIONS

Strength and conditioning coaches working with competitive surfers should consider implementing strength training with surfers. This ideally would develop effective movements through various movement and lifting patterns (e.g. squat, pull, press), and include an emphasis on developing high relative pull-up strength, as well as supplementary exercises (e.g. rotator cuff, torso, ankle-knee-hip) that would assist in effective movement and resiliency to the high volume of repetitive movements involved in surfing.

Although we found that the higher performance and older surfers had a mean LMR and relative pronated Pull-up of ~1.2, our experience and practical observations are that higher ratios could be expected to further aid in performance. For male surfers, an LMR of 1.5-2.0 and pronated Pull-Up of 1.3-1.5 is proposed to be appropriate. For example, a mature 80 kg surfer would therefore be expected to have a sum of 7 skinfolds total of 40-60 mm, with an Pull-Up strength to be between 104 kg (body-mass+24 kg)-120 kg (body-mass+40 kg). Although we have limited data on sprint paddle velocities, some of the faster times in this study were ~2.0 m/s. As such, this might represent and interesting benchmark for senior male surfers to achieve. However, this cannot be confidently asserted from this study and will require ongoing analysis with additional data sets.

Besides consideration for the coach to ensure effective technique, to improve paddling ability, conducting sprint and endurance paddling training may be appropriate. However, caution must be taken, considering that competitive surfers already perform a great deal of paddling in their structured and unstructured surf training sessions, and of course the numerous competitions they are involved in. Therefore adding a strength training program is likely to greatly compliment the overall training of competitive surfers, as it will directly improve weak musculature, very likely increase resiliency to the high volume of paddling, and achieve a high transfer to performance due to the ongoing paddle training taking place.

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