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Original research

Identifying the physical and anthropometric qualities explanatory of paddling adolescents

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Objectives: This study aimed to identify the physical and/or anthropometric qualities explanatory of adolescent surf lifesavers participating in paddling activities.
Design: Cross-sectional observational study.
Methods: A total of 53 (14–18 years) male participants were recruited and classified into two groups; paddlers (n = 30; actively participating in paddling), non-paddlers (n = 23; not actively participating in paddling). All participants completed a testing battery that consisted of 16 physical (isometric strength and muscular endurance) and anthropometric (height, mass, segment lengths and breadths) assessments. Binary logistic regression models and receiver operating characteristic curves were built to identify the physical and/or anthropometric qualities most explanatory of paddling status (two levels: 1 = paddlers, 0 = non-paddlers).
Results: Significant between group differences were noted for 14 of the 16 assessments ($P < 0.05$; $d = 0.59$–1.29). However, it was the combination of horizontal shoulder abduction isometric strength, body mass, and sitting height that provided the greatest association with paddling status (Akaike Information Criterion = 47.13). This full model successfully detected 87% and 70% of the paddlers and non-paddlers, respectively, with an area under the curve of 84.2%.
Conclusions: These results indicate that there are distinctive physical and anthropometric qualities that may be advantageous for prospective paddling athletes to possess. Practitioners should integrate assessments of horizontal shoulder abduction isometric strength, body mass, and sitting height, as well as their subsequent cut-off thresholds, into talent detection programs focused toward the recognition of performance potential in paddling-oriented sports.

1. Introduction

Differing from talent identification, talent detection is defined as the discovery of performance potential within individuals who are not currently participating within a specific sport or sporting activity.[1] The fundamental premise of a talent detection program is to test, and thus detect within a similar population (e.g. school aged children), those who possess predetermined 'gifts' (predominantly physically oriented) that may afford a talented performance within a predesignated sport or sporting activity.[1] Talent detection programs are often most effectively integrated into mono-dimensional sports (e.g. swimming, cycling, or paddling), where talented performances are primarily operationalized by mastery in a singular dimension (*i.e.*, physicality).[2] Further, talent detection programs have been used in sports which historically generate a relatively shallow participation pool from which to 'naturally' develop talent.[3] However, prior to integrating such detection programs for sports, it is crucial to identify pertinent physical and/or anthropometric markers that may position an individual for future success.

The Olympic sport of canoeing (including slalom and flat-water sprint kayaking) is one such discipline with shallow participation pools from which to identify or develop elite athletes, and therefore may benefit from talent detection strategies. The paddling action of flat-water sprint kayaking requires dynamic, forceful muscular contractions through a considerable, bilaterally symmetrical range of movement (ROM).[4] With distinctly similar kinematics, surf-ski paddling is a discipline embedded within surf lifesaving[5] that can best be described as a hybrid of the Olympic sports of flat-water sprint and slalom canoeing with competition being held in open environments.[6,7] Surf-ski paddlers often undertake flat-water kayak training to supplement their surf-ski paddling and vice versa with surf lifesaving being a common training mode for Australian and New Zealand Olympic kayaker paddlers. Given that the

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powerful upper-body demands of the paddling action require considerable strength and ROM, it could be presumed that there would be physical and/or anthropometric qualities that are explanatory of paddling performance, which could be of use for 'benchmarking' in talent detection programs. These qualities, however, are yet to be comprehensively elucidated.

Indeed, previous research has profiled the anthropometric qualities explanatory of a superior paddling performance in senior[8] and junior[9] sprint kayaking. For example, Ackland et al.[8] showed that elite senior male sprint kayakers were generally leaner, had larger upper body girths, and narrower hips when compared to the general population. Further, Alacid et al.[9] demonstrated that 14 year old male paddlers tended to possess a greater standing height, body weight, arm span and upper body lengths, breadths and girths when compared to their younger, 13 year old counterparts. However, it is important to acknowledge that this difference may have manifested from biological age variations,[10] rather than anthropometric predispositions which placed the older youngsters at a performance advantage when paddling. Despite these promising findings indicating anthropometric qualities as advantageous to paddling actions, these aforementioned studies did not assess physical qualities, such as isometric strength isolated to the lumbar spine and upper body. This is an important contributor to performance, as isometric strength qualities play a role in the stabilisation and control of the upper body during the dynamic and forceful paddling actions required for sprint kayaking.[4]

To this end, this study aimed to identify the physical and/or anthropometric qualities explanatory of paddling (canoe, kayak and surf-ski paddlers) and non-paddling adolescents. Given the dynamic and unique requirements of the paddling action, coupled with the findings of previous work,[8,9] it was hypothesised that adolescent paddlers would present distinctive physical and anthropometric qualities relative to their non-paddling counterparts. The implications of this work are vast; the predominant of which extend to the establishment of national talent detection programs focused toward the recognition of prospective paddling athletes; namely flat-water sprint kayaking and/or surf-ski paddling.

2. Methods

All participants were recruited from Australian (n = 29) and New Zealand (n = 24) surf lifesaving clubs and provided written informed consent (parental and individual) to participate in this study as approved by the institutional ethics committee. Given the access to paddling (surf-ski and flat-water sprint kayak paddling) and non-paddling adolescents in large cohorts, male adolescents (14–18 years) were recruited from surf lifesaving clubs across both Australia and New Zealand. Participants were then *a priori* categorised into two groups according to their current paddling status: 'paddlers' (n = 30), and 'non-paddlers' (n = 23). Paddling activities, and subsequently 'paddlers', were defined as those participants undertaking ≥2 sessions per week of either canoeing, kayaking (marathon, slalom or flat-water sprint) or surf-ski paddling. Non-paddlers were defined as those who had not participated in paddling activities as described above.

All participants attended a single testing session conducted in temporary testing facilities at selected surf lifesaving clubs within Australia and New Zealand. Each participant completed a demographic questionnaire detailing the type and frequency of training undertaken during the previous month. Participants then undertook a test battery consisting of 16 anthropometric and physical assessments (Supplementary Table 1). These assessments were chosen owing to their administrative feasibility for practitioners responsible for talent detection. All assessments were conducted by the same investigator.

Standing and sitting height measurements were recorded to the nearest 0.01 cm using a wall mounted stadiometer (Handy Height Scale, Mentone Educational Center, Australia). Prior to the measurement, participants were instructed to remove their footwear, placed in the Frankfort Plane, and were instructed to inhale as the measurement was recorded. Body mass was measured using a set of calibrated digital scales (Tanita TBF-521, Tanita Corporation, Tokyo) with measurements being recorded to the nearest 0.1 kg. Participants were instructed to remove their footwear prior to this measurement, but were permitted to wear their training shorts and singlet. All limb segment lengths and breadths were measured as per standardised international guidelines,[11] and were conducted using appropriate anthropometric equipment (Harpenden Anthropometer, Holtain Ltd., Crosswell, UK). The isometric strength tests (handgrip, horizontal shoulder adduction/abduction, and lumbar back) were assessed via manual dynamometry with muscular strength-endurance being assessed via a 60 s sit-up and a 60 s push-up test as per standardised protocols.[12] Further, abdominal strength was assessed via the 7-stage sit up test.[13]

Descriptive statistics (mean and standard deviation; SD) for each physical and anthropometric assessment were calculated for both groups; paddlers and non-paddlers. All data were visualized and modelled using *R* version 3.2.2.[14] The data were plotted using a scatter plot overlayed within a violin plot to granulate the underlying distribution of the data. Violin plots show the probability density distributions of the data and provide a comprehensive visualization of the data with respect to skewness and modality. Following this, a multivariate analysis of variance (MANOVA) was used to test the main effect of paddling status (two levels: paddlers, non-paddlers) on the physical and anthropometric assessment criterions. The effect size of paddling status on the physical and anthropometric assessment criterions was calculated using Cohen's d statistic, where an effect size of $d = 0.20$ was considered small, $d = 0.50$ moderate and $d > 0.80$ large.[15] The type-I error rate was set at $\alpha < 0.05$.

Binary logistic regression models were then built to identify the physical and/or anthropometric assessments most explanatory of the main effect; with paddling status coded as the binary response variable (0 = non-paddlers, 1 = paddlers). The physical and/or anthropometric assessments that significantly differed according to the MANOVA were then included as the explanatory variables in the full model. Model parsimony was established by reducing the full model using the 'dredge' function in the *MuMIn* package.[16] This function returns the best model using the Akaike information criterion.[17] To provide a relative reference frame for model parsimony, a null model was built with its parameter estimates being used as a comparator.

To assess the level of discrimination shown by the most parsimonious full model and its single term contributors, the *pROC* package[18] was used to conduct sensitivity versus specificity analysis. Thus, receiver operating characteristic (ROC) curves were built with the area under the curve (AUC) being calculated. An AUC of 100% (1) represents perfect discrimination for a binary response variable, which in this case, was paddling status. The point on the curve which generates the greatest AUC can be considered the point at which a 'cut-off' might be acceptable for detecting potential paddling athletes. The ROC curve produced a cut-off by using the total score generated by the most parsimonious full model and for its single term contributors.

3. Results

The visualized data properties for the physical and anthropometric assessments are illustrated in Supplementary Fig. 1. The 14 physical and anthropometric assessments that yielded significant