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Original article

Ulnar variance related to biological and training characteristics, pain and handgrip strength in Portuguese skeletally immature male gymnasts

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Abstract

Purpose: This study was to investigate the association between ulnar variance (UV) and biological and training characteristics, handgrip, and wrist pain in a group of 23 Portuguese skeletally immature male gymnasts (aged 11.2 ± 2.5 years).
Methods: Left and right UV was obtained using Hafner's procedure and skeletal age was determined by the Tanner–Whitehouse 3-method. A negative mean value for UV measures was observed (−2.4 to −3.6 mm) without significant differences with increasing age-category ($p = 0.09$ to $p = 0.48$). Significant low correlations were observed between some UV parameters and stature, fat percentage, years of training, and left handgrip strength.
Results: Ten gymnasts reported wrist pain with gradual onset and UV values were very similar between painless and painful wrists.
Conclusion: The findings of this study do not directly support the thesis that gymnastics training and biological variables or wrist pain are associated with UV.

Keywords: Gymnasts; Pain; Training; Ulnar variance

1. Introduction

Artistic gymnastics (AG) is a sport characterized by involvement at an early age,[1–3] with a relatively rapid transition to high-volume, high-impact training.[3,4]

AG requires long hours of practice and repetitions of movements,[5] as well as high ability of strength, flexibility and balance to learn complex and high-level skills.[6] It is unique among all athletic endeavors in the demands it places on the upper extremities.[7] AG requires conversion of the upper limb into load-bearing extremities, leading to upper extremity injuries, especially on the wrists.[8–10] In fact, since nearly all gymnasts enter the sport at a young age, the wrist growth plates are potential sites for injuries.[1,11,12] The immature musculoskeletal system, submitted to repetitive biomechanical stress, becomes more vulnerable and may lead to overuse injuries.[6,13,14] Repetitive trauma to the radial physis can lead to a premature partial or complete closure of the growth plate or retarded radial growth.[8,15] It has also been theorized that the increased loading during growth and development of the distal radial physis will result in wrist pain,[11,16] in length discrepancy[1] and an increased incidence of positive ulnar variance (UV),[7,11,17] which are "gymnastics-specific" characteristics.[5,18]

Male gymnasts present more injuries at the upper limbs in contrast to the female,[18–20] probably due to the fact that men's

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gymnastics is comprised by six apparatus, all of which producing load on the wrists.[19]

Little is known about the relationship between some specific UV changes, and arm muscle strength, hand dominance or wrist pain. Wrist pain is common among both elite and non-elite male gymnasts,[8,16] although the specific etiology is often difficult to determine.[15,16] Eventually, there might be a certain predisposition for the occurrence of injuries in a particular side,[5] which may reflect the fact that gymnasts have a preferred side when performing.[17] Some authors state that UV can vary from side to side in an individual, resulting in significant right-left differences.[12,21–23] Studies concerning the impact of gymnastic training on the UV phenomenon are mostly concentrated on female gymnasts. Studies on male gymnasts are rather scarce, and the obtained results are univocal.

The purposes of this study were: (a) to evaluate the relationship between training and biological characteristics and UV in Portuguese skeletally immature male gymnasts; and (b) to observe wrist pain status in relation with UV and handgrip strength in this group of gymnasts.

2. Methods

2.1. Participants

The sample consisted of 23 Portuguese skeletally immature male artistic gymnasts from clubs nearby Porto and Lisbon, varying in chronological age from 7.2 years until 16.0 years, with a mean age of 11.2 ± 2.5 years, competing at national and/or international levels. Gymnasts have begun their practice with a mean age of 6.0 ± 1.9 years.

These subjects were divided into three groups according to their age: "Beginners/Advanced", aged 6–10 years (group A, $n = 9$); "Performers", aged 11–14 years (group B, $n = 12$); and "Elite Juniors and Seniors", aged ≥ 15 years (group C, $n = 2$). These competition levels are defined by the Portuguese Federation of Gymnastics (FGP) in accordance to the Age Group Development Program (AGDP) from the International Gymnastics Federation.[24] However, to avoid analyses and comparisons with a very small group of two individuals from the Elite Juniors/Seniors group we included them into group B. This choice leads us to work with only two groups (group A, $n = 9$; group B, $n = 14$) instead of the three beginning groups mentioned.

The Ethical Committee of the Faculty of Sport Sciences from the University of Porto approved this protocol and an informed consent was also obtained from all gymnasts or gymnasts' parents and personal coaches were informed.

2.2. Variables and measuring procedures

2.2.1. Anthropometry and body composition

Stature was measured with a stadiometer Seca 202 (Seca Gmgh & co. kg., Hamburg, Germany) with an accuracy of 1 mm. Body mass was obtained with a scale (Seca) accurate to 0.1 kg. Measurements were taken by the same experienced observer (LA) following the procedures described by Claessens et al.[25] Body mass index (BMI) was calculated as body mass divided by stature (kg/m^2).

Body composition components fat-free mass (FFM, kg) and percentage of body fat mass (Fat, %) were obtained by means of bio-electrical impedance analysis using the Tanita BC 418 MA Segmental Body Composition Analyzer (Tokyo, Japan). This device takes into account chronological age of the subjects and the guidelines suggest categorizing individuals into two activity levels: standard and athlete.[26]

2.2.2. Skeletal maturity

Maturity status refers to the individuals' state of maturation at a given point in time, specifically by the skeletal age (SA) attained at a specific chronological age (CA).[27,28] Skeletal maturity is equivalent to the difference between SA and CA (SA−CA) and it can be advanced or early maturing (above 1.0 year), delayed or late maturing (below 1.0 year) and "on time" or in average maturing (within ±1 year).[27] To estimate SA, the Tanner−Whitehouse 3 (TW3)-method was used, with the radius, ulna, and short (RUS) bone system.[29] Standardized radiographs of the left hand and wrists were taken according to the recommendations given by Tanner et al.[29] SA assessment was made by an orthopedist with experience in the TW3-method. To assess intra-observer reliability 15 wrists were measured twice and the intra-class correlation coefficient was very high ($R = 0.999$, 95% CI = 0.998−1.000).

2.2.3. Ulnar variance determination

UV measuring was done on both right and left radiographs (posteroanterior radiographs of wrists with forearm in neutral rotation, the elbow at 90° flexion and the shoulder at 90° abducted),[30] with Hafner and co-workers'[31] method for immature subjects. The subjects were classified into three UV categories: (a) when the relative length of the distal radius and the relative length of the distal ulna differed by less than 1 mm, UV was considered neutral; (b) when the length of the distal ulna exceeded that of the distal radius by 1 mm or more, UV was considered positive; (c) when the length of the distal ulna was inferior to that of the distal radius by 1 mm or more, UV was classified as negative.[22]

All measurements were taken by the same observer (LA). To assess intra-observer reliability 15 X-rays were marked and measured twice in a blind fashion. There were no significant differences for both variables, and intra-class correlations between readings were high ($R = 0.971$, 95%CI = 0.912 − 0.991 for the distance from the most distal point of the ulnar metaphysis to the distal point of the radial metaphysis (DIDI); $R = 0.987$, 95%CI = 0.962 − 0.996 for the distance from the most proximal point of the ulnar metaphysis to the most proximal point of the radial metaphysis (PRPR)).

2.2.4. Training data and handgrip strength

The senior author collected the training data using individual interviews with gymnasts and confirming the data collected with their coach to reassure that the information was accurate.

Handgrip strength of both left and right hands were measured using a mechanical handgrip dynamometer (Takei Kiki Kogyo