Orthopaedics & Traumatology: Surgery & Research 100S (2014) S355–S360

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Review article

The human acromion viewed from an evolutionary perspective

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ARTICLE INFO

Article history:
Accepted 17 September 2014

Keywords:
Acromion
Paleo-anthropology
Rotator cuff
Scapula

ABSTRACT

The high prevalence of rotator cuff tendinopathy in modern humans may be partly related to the shape acquired by the scapula as species changed throughout evolution. Here, we compared the anatomic features of the scapula across members of the Hominoid group. The results support the hypothesis that the scapula of *Homo sapiens sapiens* exhibits distinctive anatomic characteristics compared to that of other Hominoids. We studied 89 scapulae from five species. For each scapula, we measured eight parameters and determined six index. We then compared the results across species. We identified two distinctive characteristics of the lateral aspect of the human scapula, namely, a lateral orientation of the glenoid cavity and a narrow coraco-acromial arch. Similar to the gorilla acromion, the human one is steeply sloped and, above all, larger and squarer than the acromion of other Hominoids. These features may explain, in part at least, the pathogenesis of rotator cuff tendinopathy in modern man.

1. Introduction

The high prevalence of rotator cuff tendinopathy probably reflects a mismatch between the anatomic characteristics of the shoulder of *Homo sapiens sapiens* (HSS or modern man) and the work imposed on the shoulder in terms of both loads and duration. Many studies have sought to identify the specific anatomic characteristics of the shoulder, most notably in primates [1–10]. In the Primates order, HSS is classified with the apes (gibbons, orang-utans, gorillas, and chimpanzees) within the taxon Hominoids (Fig. 1). Their scapulae share a number of features, which are probably related to the loss of strict quadrupedalism and to the development of directed hand motions. Some other features are specific of HSS, which is the only strictly bipedal Hominoid [11–14]. These features involve the position and shape of the scapula. Apart from primates, few mammals have clavicles, which allow upper limb movements outside the parasagittal plane [15]. The shape of the clavicle dictates the position of the scapula relative to the rib cage, which is posterior in Hominoids and lateral in Cercopithecoids [12,16]. Cercopithecoids, which are not hominoids, are all quadrupeds (both on the ground and in trees) and their limbs therefore work chiefly in compression. Their scapulae are positioned laterally and are relatively elongated, with underdeveloped supraspinatous and infraspinatous fossae, a small acromion, and a narrow glenoid cavity. These features are reminiscent of those seen in quadrupedal mammals such as cats and dogs [17]. In contrast, primates that use suspensory locomotion such as apes have broad scapulae with well-developed supraspinatous and infraspinatous fossae and a longer and broader acromion compared to that of quadrupedal primates. This shape increases the surface area of the deltoid muscle attachment [17,18]. The HSS scapula is characterized by high dorsalization in regard to the thorax and infraspinatous fossa further developed, together with a proportionally smaller supraspinatous fossa [7,8,12,14,17] (Fig. 2). Because the number of available fossilised scapulae from Homininae (the human lineage within the hominoids) is small, the time at which this anatomic specialisation occurred during the evolutionary process remains unknown. Information can be obtained only by performing comparative anatomical studies.

The aim of this original preliminary study was to obtain the first comparative data on the anatomic features of the lateral aspect of the scapula within the group of Hominoids (HSS and apes) and to discuss the impact of these features on function. Our hypothesis was that the HSS acromion exhibited specific anatomic features that might explain, at least in part, the high prevalence of tendinopathy in HSS.

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http://dx.doi.org/10.1016/j.otsr.2014.09.011
1877-0568/

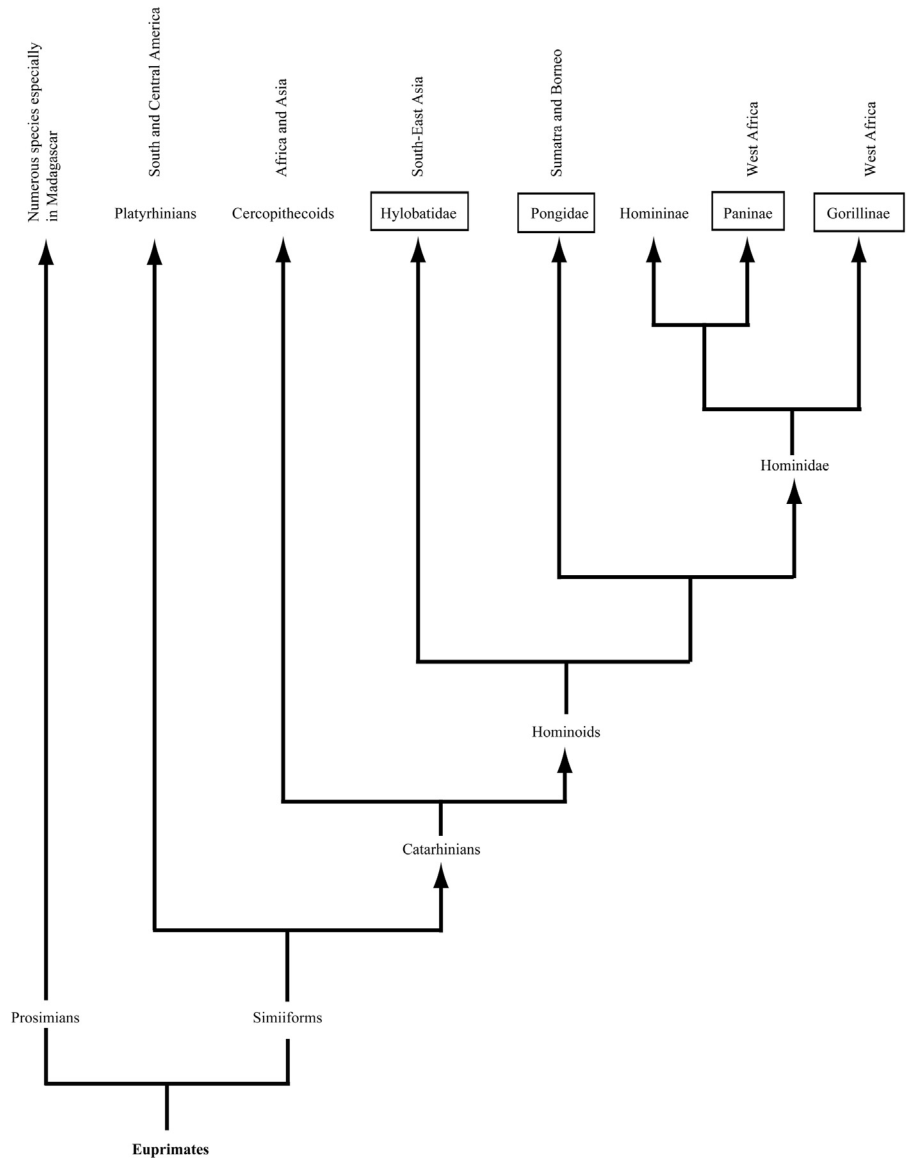

Fig. 1. Phylogenetic tree for Euprimates (anthropoid and pro-simian primates). *Homo sapiens sapiens* belongs to the Homininae subfamily and is closely related to the apes within the Hominoids, particularly the species found in Africa (Hominidae). Words framed: Apes, which is a paraphyletic group.

2. Material and methods

We studied human scapulae from the anthropology collection of the *Musée de l'Homme*, Paris, France; and ape scapulae from the zoology collection of the *Département d'Anatomie Comparée du Muséum National d'Histoire Naturelle*, Paris, France. Table 1 lists the species selected for the study. We used the classification of primates developed by Rowe [19], which recognises a single species of gorilla (*Gorilla gorilla*) and two separate species of orang-utan, one on Sumatra (*Pongo abelii*) and the other on Borneo (*Pongo pygmaeus*).

We used callipers to obtain the seven measurements, in millimetres, reported in Fig. 3. These measurements were used to compute six ratios or surface areas (Table 2) in order to characterise bone processes as long or short and broad or narrow independently from absolute measurement values, which varied with the size of the species. We used a protractor to measure the slope of the acromion (h) and orientation of the glenoid cavity (i) in degrees [12].

Statistical analyses were performed using PAST 2.17 software® [20]. The values of the morphological index and slopes were compared across groups. Because of the small sample sizes, most of the values were not normally distributed, and we therefore used the non-parametric Kruskal-Wallis test for comparisons. According to the null hypothesis, the overall sample came from populations having identical median values with the α risk set at 5%.

Table 1
Species and number of scapulae studied.

Species	Number of scapulae
Gibbon	
Hylobates sp.	7
H. gabrielli	2
H. moloch	2
Orang-utan	
Pongo pygmaeus	9
Gorilla	
Gorilla gorilla	21
Common chimpanzee	
Pan troglodytes	22
Human	
Homo sapiens sapiens	26