Human Biology Review
www.humanbiologyjournal.com

Human Biology Review (ISSN 22774424) 10(2) 2021
Original scientific paper (Adheke 107-113)
Modified and Accepted on February 23, 2021

Pollical Palmar Interosseous Muscle (PPIM) of Henle: The evolution of handgrip in primates and implications in human biology

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Citation: Adheke OM. 2021. Pollical Palmar Interosseous Muscle (PPIM) of Henle: The evolution of handgrip in primates and implications in human biology. Human Biology Review, 10 (2), 107-113.

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ABSTRACT

The study of musculoskeletal variations has systematically improved overtime in the study of vertebrate anatomy and human biology. Primates possess features that are uniquely relevant compared to other vertebrates. One of such features is the ability of their prehensile hands to form handgrip manipulations. Grip actions however, differ among primates and this current study seeks to possibly suggest how the pollical palmer interosseous muscle (PPIM) plays a significant role in ensuring these grip morphological differences between humans and non-human primates.

Keywords*: Musculoskeletal variations, human biology, handgrip, PPIM.*

INTRODUCTION

The study of evolutionary changes in the morphology of body organs and tissues in primate species has broadened the scope of comparative anatomy and human biology. There are certain muscles that were known to have been lost in our ancestors well before the evolution into modern humans and these changes either brought about muscle variations in adult human populations or presented as anomalies in individuals with congenital defects (Boyle et al., 2020).

The human hand unlike other primates is uniquely made for carrying out different manipulations such as carrying, squeezing and gripping (Mitsionis et al., 2009). Generally, the gripping ability of the hands of primates is attributed to the morphological evolution of the thumb and the other four individual digits opposed to it (Fragaszy, 1998). In humans, the commonest forms of grip that are exhibited include the power and precision grips (Marzke, 1997). Power grips are formed by holding an object as a clamp between the flexed fingers and the palm while precision grips are

done by gripping an object between the palmar aspect of the terminal phalanx of the finger or fingers and the thumb (Napier, 1960). Power grips are usually carried out by almost all primate species unlike precision grips that are majorly done by humans (Welles, 1976). These unique differences can be due to the musculoskeletal orientations of the human hand in comparison with the hands of other primates (Tuttle, 1969, 1981).

The Pollical Palmar Interosseous Muscle (PPIM) of Henle and associated palmar interossei muscles.

A major component of the intrinsic group of hand muscles are the interossei muscles, which act by adducting and abducting the fingers. These interrosei muscles are grouped into two; palmar interossei – which are responsible for adduction of fingers and the dorsal interossei – acting by abduction. Overtime, it has been reported that there are three palmar interossei, each originating at the medial or lateral surface of the second, fourth and fifth metacarpals and inserting at the bases of the 2nd – 4th digits of the hand (Valenzuela & Varacallo, 2020). However, recent studies have shown that there is a presence of a palmar interosseous muscle on the medial surface of the first metacarpal termed the pollical palmar interroseous muscle (PPIM), which according to these reports have been found to be present in over 85% of specimens that have been cadaverically studied upon (Susman et al., 1999; Morrison & Hill, 2011; Bello-Hellogouarch et al., 2012).

PPIM, formally known as volaris primus of Henle, was first discovered by the German anatomist, Friedrich Gustav Jakob Henle in 1858. Henle found the PPIM and identified it as the first volar (palmar) interosseous (Henle, 1858). Subsequently, other authors supported Henle's findings by reporting on their own cadaveric observations that PPIM existed as small remnant of another palmar interroseous muscle that is closely related to the thumb (Lewis, 1965; Romanes, 1966; Moore, 1985; Stern, 1988; Snell, 1996). However, other authors still have contrasting views on the presence of PPIM as they maintain that there are only three palmar interossei (Gosling et al., 1985; Basmajian & Slonecker, 1989; Lippert, 1990; Hall-Craggs, 1995; Moore & Agur, 1996). Some authors also regard the PPIM as part of the oblique head of the adductor pollicis muscle and not as a single muscle (Hollinshead & Roose, 1985; Mardell & Underwood, 1991; Zancolli, 1992) while others regard it as part of the flexor pollicis brevis (Wood-Jones, 1949; Crafts, 1985).

This review seeks to explore the possible roles that PPIM play in the gripping activity of the hand where present and to understand how the concept of human biological evolution might have played a role in the varying perceptions of anatomists regarding the presence or absence of the PPIM.

PPIM in relation to Anatomy and Evolutionary Biology.

A study by Diogo et al. (2012) reported that with respect to the muscular anatomy of the forearm and the hand, there are four key anatomical features that differentiate modern humans from non-human primates; a true flexor pollicis longus, a deep head of flexor pollicis brevis, an extensor pollicis brevis and a volar interosseous of Henle (also called the PPIM). Having noted that, most human anatomy texts and atlases have yet failed to recognize the PPIM as an intrinsic muscle of the hand despite reports that have been shown to prove otherwise (Lewis, 1989; Susman et al., 1999; Morrison & Hill, 2011; Bello-Hellogouarch et al., 2012). This could be attributed to the confusions and controversies that are still surrounding the classification of muscles of the forearm and hand. The concept of anatomical variations in human and comparative anatomy cannot be overemphasized enough.

Susman et al (1999) proposed that the PPIM is found in humans as a result of the use of tools during the process of evolution. According to Diogo & Wood (2011), the PPIM is derived from a thin deep additional slip of the adductor pollicis and is found in Homininae such as African great apes and modern humans, whereas in other primates, they are almost absent. However, Diogo et al (2012) were able to find out from their study that PPIM was present in less than 50% of primates such as chimpanzees and gorillas. The thumb of a chimpanzee hand is relatively small and highly immobile, with the other fingers robust in shape (Lewis, 1977; Suswan, 1979). In regards to this, it can be suggested that the PPIM contributes significantly to the adduction of the thumb in modern humans – although, there is need to understand the phylogenetic basis of this muscle to fully accept this proposed function. This is due to the existing notion that the muscle, adductor pollicis, is known as the thumb's adductor (Stranding, 2008).

Furthermore, with reference to the homogeny of the PPIM, the works of Lewis and Diogo and colleagues were able to provide some degree of insights on how the human hand had undergone certain evolutionary changes from ancestral primates (Lewis, 1965; 1989; Diogo et al., 2009; Diogo and Abdala, 2010).

Possible role of PPIM in Handgrip action in humans and non-human primates

The handgrip orientations that are produced by humans differ significantly from that of other nonhuman primates. Napier (1960), in his study, observed these differences when he compared the grip of humans to that of chimpanzees. Chimpanzees are able to suspend while they hold on to tree branches by the formation of hook grips (Napier, 1960; Marzke and Wallstein, 1996). Although, these hook grips do not completely allow these chimpanzees to squeeze their palm against their fingers, they however help them to cling to these trees. However, they lend to lose these grips on the trees easily due to the weakness of the thumb (Marzke et al., 1992). It is possible that the presence of PPIM would help to strengthen these hook grips produced by these chimpanzees and other non-human primates.

The earliest human species known to be the Australopithecus hominids, were known to share similar hand musculoskeletal features to non-human primates such as chimpanzees and apes. However, it is reported that one feature that was unique to the Australopithecus africanus is the presence of a deep impression of the flexor pollicis longus tendon on the volar surface of the distal thumb phalanx (Diogo et al., 2012). This impression could be said to be the PPIM as its point of attachment is similar to that of modern humans which partly contributes to the grip morphology of the hands. This feature could have resulted from evolutionary changes due to tool use and the transition from partial quadripedalism to bipedalism (Hunt, 1994).

Conclusion

The PPIM, despite contrasting perceptions by anatomists and human biologists, is recognized as part of the interrossei group of intrinsic muscles of the hand and that due to the nature of origin and insertion of this muscle, it plays a role in the formation of precision and power grips in humans as well as other hand manipulations. For future research, it is important to see how this muscle contributes to the effectiveness of hand use in various activities such as sports, handwriting, etc.

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