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Muscle architecture a new dimension of talent identification: A mini review

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Abstract
Talent Identification in the field of exercise science is growing exponentially, where muscle is considered as most reliable method for determining muscle fiber type and selecting sports activity accordingly. Muscle architecture a new fiber type determination technique is now in trend, which refers to the macroscopic arrangement of muscle fibres that influences a muscle's mechanical function. Previous research has shown a relationship between muscle architecture (such as fascicle length, muscle thickness, and pennation angle) and muscle fibre types (e.g. slow twitch fibres and fast twitch fibers). This small review attempts to briefly discuss how muscle architecture has been investigated in the realm of sport/exercise performance, as well as how various muscle fibre types have varied muscle architecture characteristics.

Keywords: Talent identification, muscle architecture, PCSA, Pennation angle, fascicle length and muscle thickness

Introduction

Talent identification in sports: Talent identification and development is a growing topic of sport research. Only gifted individuals can be trained to win medals in international competition. Talent requires years of hard work and dedication. Sport talent is the sum of an athlete's pre-requisites (and potential for improvement) that enables them to perform well in a sport competition. Prerequisites include motor, technical, tactical, physical, personality, reasons, and interests (Singh Hardyal, 1991) [29].

It is possible to identify talent in a very simple or sophisticated manner. For example, a high school basketball coach may recruit players based on their height. This physical capability is required for an efficient kick, so a school swimming coach wandering around the playground may see children standing with large pronated feet. Advanced programmes, on the other hand, are focused on sports science and medicine, with a thorough test battery used to examine young athletes. As a matter of routine, many developed countries employ the latest science to identify and choose promising athletes in particular disciplines. Unfortunately, India has not paid attention to this particular issue. Due to this, athletes are mostly selected from the existing pool based on their current performance, whether it is done in competitions or through fitness-based assessments. In spite of this thorough grooming process, many "talented" athletes have already hit their peak; hence, new look is required to do better on the selection process for Indian athletes. The problem is to find out whether one has a need earlier in life (Brar, 1987) [5].

Environmental and genetic variables impact athletic ability. Modeling is the study of goal-setting. Several patterns or models can assist detect athletic potential. Systemic thinking helps find talent. Diverse groups and people help this process succeed. These systematic and focused systems employ proper models. Talent discovery and development models differ. Talent identification systems have focused on spotting remarkable talents and choosing gifted people. Gimbel, Harre, Matsudo, Peltola, Abbott and Collins, Côté *et al.*, Vaeyens *et al.*, Burgess and Naughton, and Houlihan and Chapman propose talent detection models. These models identify people based on criteria and parameters and predict their future performance. Much talent detection research has focused on sports. Most research addressed anthropometric and physiological factors (Loghman *et al.*, 2019) [20].

Talent identification process

The aim of the talent identification process is to identify and develop promising young talent while also expediting its development. This identification process consists of a number of complex processes, during which a novice strives to become a top-level sportsperson. The following Fig 1 explains the process of talent identification.

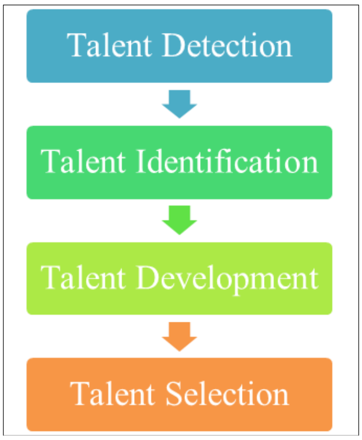

Fig 1: Adapted from Williams and Reilly (2000) The Stages of the "pursuit of excellence"

The detection of potential talent is the first step in the talent identification process. In the early stages of talent identification, researchers look for potential performers who are not actively involved in any sports. Following the detection of talent, it is critical to identify existing participants who have the potential to achieve elite performance and to nurture them in a proper learning and nurturing environment so that their potential can be realized. Final phase in this procedure involves screening athletes who are actively engaged in sports with the help of an experienced coach or a specified test to identify those who have the best chance of succeeding.

Talent identification in India

Sports Authority of India (SAI) was established in 1985 and around that time, a variety of initiatives, such as the National Sports Talent Competition (NSTC), Special Area Games (SAG), Army Boys Sports Company (ABSC), and so on, were introduced, with the primary goal of identifying and selecting talented young athletes to be placed in special training centers. Because of this, the test used to pick candidates had a lot of backlash, as the scientific criteria for talent selection were practically non-existent in these methods. Prior to the birth of brilliant children, the selection of such candidates was carried out by means of tournament and competition. Some gifted children have already reached their top level of performance, and any potential for advancement has been largely squandered due to their hectic schedules (Asteya, 2016) [3].

Muscle Fiber Types

Early in the twentieth century, the technique of muscle biopsy was developed for the study of muscular dystrophy. It was developed in the 1960s to sample muscles for use in exercise physiology research, specifically to determine the muscle fiber types Slow oxidative (SO) Type 1, Fast oxidative glycolytic (FOG) Type 2a, and Fast glycolytic (FG) Type 2x.

In light of the fact that there is no way to directly determine the fiber type composition of an individual except through the use of an invasive muscle biopsy test (in which a hollow needle is inserted into the muscle and a core sample of muscle fiber is extracted for examination under a microscope), some researchers have attempted to indirectly estimate the fiber type composition within muscle groups of an individual by testing for a relationship between the different properties of fiber type and muscle composition. It has been discovered that there are strong connections between the fraction of FT fibers in the muscle and muscular strength or power in studies conducted with iso-kinetic dynamometers or electrical stimulation (Coyle, E.F., D.L. Costill, 1979; Froese, E.A., 1985; Gerdle, B., M.L. Wretling, 1988; Gregor, R.J., V.R. Edgerton, J.J. Perrine, D.S. Campion, 1979; Suter, E., W. Herzog, J. Sokolosky, J.P. Wiley, 1993) [6, 10, 11, 12, 30].

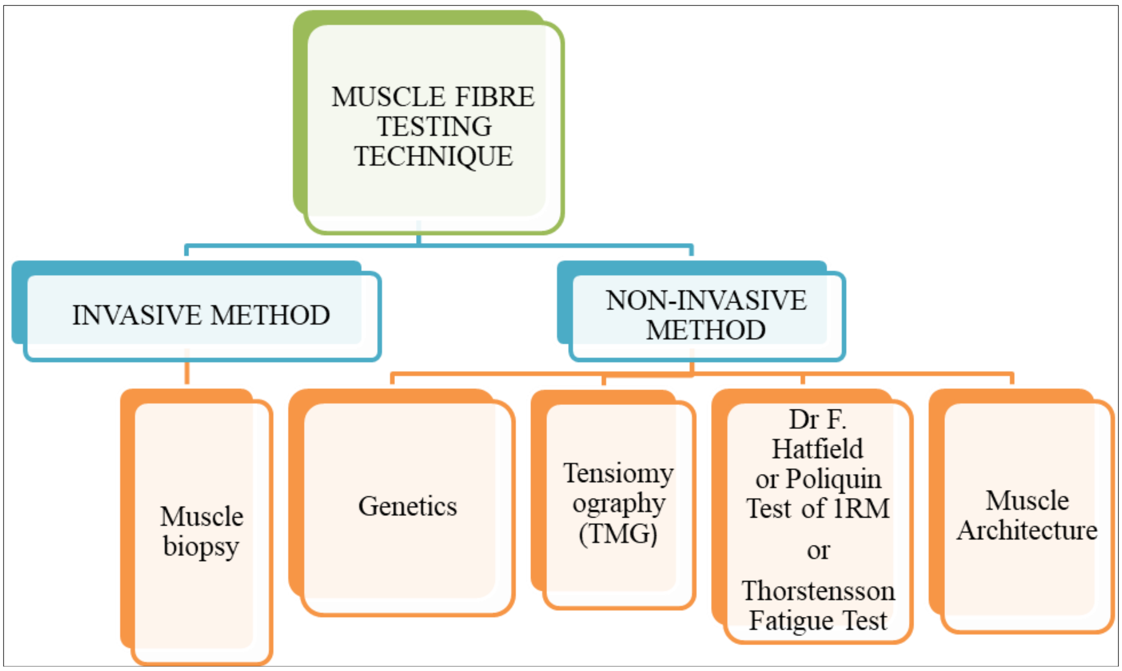

Fig 2: Methods for identifying muscle fiber type.

By employing a technique known as gel-electrophoresis, a newer technique for distinguishing fibre type can be achieved by chemically separating the different types of myosin molecule (isoform) present in the muscle. Type 1 and type 2 fibres are distinguished by their weight separation in an electric field, whereas type 2a and type 2x fibres are distinguished by their shape separation in an electrical field.

Accurate determination of muscle fiber composition is invasive and expensive, while in-direct measurement approaches necessitate the use of specialized resources and skills to be effective (Hall *et al*., 2021) [13].

Tensiomyography (TMG) is a new technique for determining the type of muscle fibers on the basis of the contractile properties of skeletal muscle fibers. When performing tensiomyography, the mechanical response of the muscles is measured by the amount of radial muscle belly displacement caused by a single electrical stimulus. Alternative methods to determine approximate fiber composition using strength training equipment may be useful for fitness professionals and coaches who do not have access to laboratory equipment. This method may be useful in directing future training for fitness professionals and coaches who do not have access to laboratory equipment. To begin, determine the athlete's one-rep max (or 1RM) for several activities. For each of the exercises, athletes complete as many repetitions as possible at 80 percent of their one-rep maximum (RMP). If athletes is only able to complete a few repetitions (e.g., 7), then the muscle group is most likely made of more than 50% FT fibers. If he or she is able to complete a large number of repetitions (>12), then the muscle group most likely contains more than 50% ST fibers. If the person can complete between seven and twelve repetitions, it is likely that the muscle group contains an equivalent proportion of fibers (Pipes, 1994) [26].

In order to successfully predict human movement and athletic performance, one of the most significant and dependable critical characteristics is muscle architecture. (Abe *et al*., 2001; Ema, R., Wakahara, T., Yanaka, T., Kanehisa, H. & Kawakami, 2016; Ericson, M. O., Bratt, A., Nisell, R., Arborelius, U. P. & Ekholm, 1986; Kordi, 2017; Lieber, R. L. & Friden, 2001; Nadzalan *et al*., 2017; Salimin, 2018) [2, 8, 9, 16, 24, 28] Muscle architecture was originally defined by Gans and De Vries. The macroscopic arrangement of muscle fibres that regulates a muscle's mechanical function is referred as the muscle architecture. Ref. Fig. No.1 & 2. Muscle architecture parameters include physiological cross-sectional area (PCSA), Pennation angle (PA), Fiber Length/ Fascicle Length (FL), and Muscle Thickness (MT). (Salimin, 2018) [28].

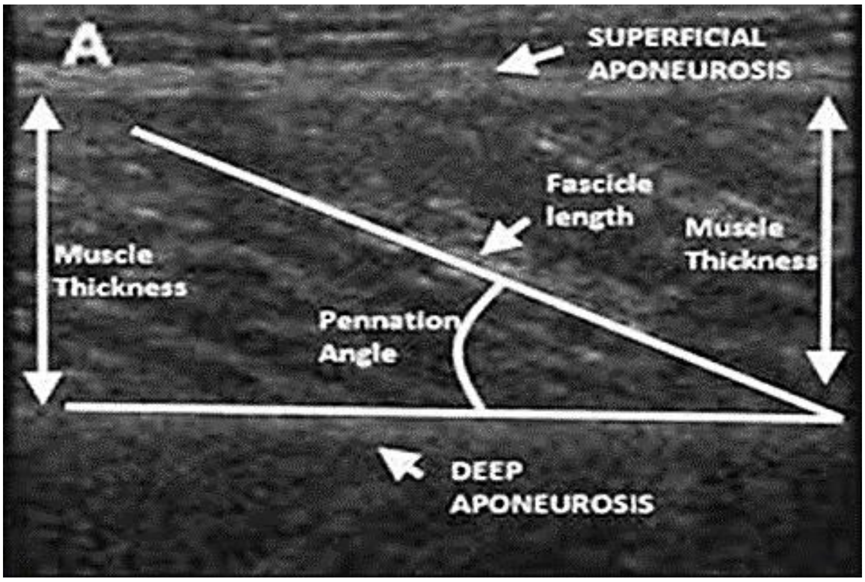

Fig 1: Vastus Lateralis muscle architectural parameters.

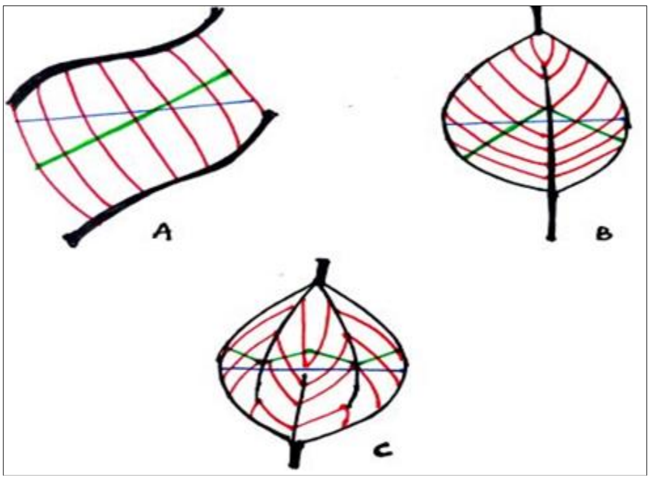

Fig 2: Physiological cross-sectional area (PCSA) and anatomical cross-section area (ACSA).

Physiological cross-sectional area is the area of a muscle's cross section taken perpendicular to its fibers, which is usually the greatest point on the muscle's cross section. "The muscle cross-sectional area (blue line in figure 2, also known as anatomical cross-section area, or ACSA) does not accurately represent the number of muscle fibers in the muscle. A better estimate is provided by the total area of the cross-sections perpendicular to the muscle fibers (green lines in figure 2). This measure is known as the physiological cross-sectional area (PCSA), and is commonly calculated and defined by the following formula, developed in 1975 by Alexander and Vernon." (Maganaris C.N., 2000; Narici M.V., Landoni L., 1992; R. McN. Alexander, 1975) [31, 25, 27].

$$\text{Physiological Cross-Sectional Area} = \frac{\text{Muscle Volume}}{\text{Muscle Fiber Length}}$$

Pennation angle is defined as the angle between a fascicle's orientation and the tendon axis. (Salimin, 2018) [28] Muscle fiber length is defined as the distance from the origin of the most proximal muscle fibers to the insertion of the most distal muscle fibers. (Kumagai *et al.*, 2000) [17] Muscle thickness is defined as the thickness between two fascias of muscle. In general thickness considered as the main factor for determining muscle size. (Abe *et al*., 2001) [2] Muscle thickness, muscle volume, pennation angle, and fascicle length are all tightly correlated to maximal muscle strength and power. (Kumagai *et al*., 2000; Lee *et al*., 2021; Salimin, 2018) [17, 18, 28].

Muscle Architecture Relationship with Fiber Types

Scientific studies on muscular architecture are currently trending in this time. Various architectural variables and their relationship with sports are briefly described. Muscle force is directly related to physiological cross-sectional area. Muscle velocity is inversely related to the length of the muscle fibers. Sprinters have longer fascicles than distance runners, and this is reflected in their leg muscle length. Sprinters' leg muscles have a longer fascicle length (vastus lateralis) and a smaller pennation angle than the general population. Greater pennation angle permits a greater quantity of contractile tissue to bind to a given piece of tendon, or aponeurosis, thus increasing the physiological cross-sectional area of a muscle (Blazevich AJ, Coleman DR, Horne S, 2009; K Albracht, A Arampatzis, 2008; M M Bamman, B R Newcomer, D E Larson-Meyer, R L Weinsier, 2000) [4, 15, 21].

The increment in pennation angle will causes a cross sectional area of muscle to have more number of fibers. This will therefore boost the muscular ability to produce more force. (Manal K, Roberts DP, 2006) [23] discovered pennation angle to be linked with muscle thickness and improvement in strength. However, a increment of pennation angle with constant cross-sectional area has been reported to cause reduction of strength (Ikegawa S, Funato K, Tsunoda N, Kanehisa H, 2008) [14]. This condition was assumed to be influenced by the angle of pull of the fibers that is indirect to the draw of the muscle in total, and thus cause the pull of the muscle in total lowered by the cosine of the pennation angle.

Fascicle length is the distance of fascicle from aponeurosis to another aponeurosis. Mathematically, it is a product of fascicle thickness and pennation angle. Fascicle length will be increased with the increment of muscle thickness and decrement of pennation angle. A difference in muscle thickness in the leg muscles (vastus lateralis, gastrocnemius medials and lateralis) is a significant element in distinguishing sprinters from long distance runners (Salimin, 2018) [28]. There is a significant negative correlation between 1RM (one-repetition maximum) lunges performance and the pennation angle of the Rectus Femoris, Vastus Lateralis, and Vastus Medialis muscles, indicating that a smaller pennation angle is associated with better lunges performance. There is a significant positive correlation between 1RM lunges performance and the fascicle length for RF, VL, and VM muscles, suggesting that longer muscle fascicles contribute to better performance in lunges. There is a significant positive correlation between 1RM lunges performance and muscle thickness for the RF, VL, and VM muscles, indicating that greater muscle thickness is associated with better lunges performance. (Kumar, 2022) [32]

(Earp, Jacob E; Kraemer, William J; Newton, Robert U; Comstock, Brett A; Fragala, n.d.) [7] in contrast to (Abe, T., Kumagai, K. & Brechue, 2000; Kumagai *et al*., 2000) [1, 17] investigations, observed that greater muscle thickness and pennation, as well as shorter fascicles, were favourable for leaping ability at higher pre-stretch loads. These findings revealed that more pennation and shorter fascicles were linked to improved leaping performance at higher pre-stretch loads, highlighting the importance of training specialisation.

According to (Earp, Jacob E; Kraemer, William J; Newton, Robert U; Comstock, Brett A; Fragala, n.d.; Nadzalan *et al*., 2017) [7] lunge performance improved with larger muscle thickness and pennation angle when determined by 1RM score. These disparate results showed that muscle architecture varies depending on the individual's training and the exercise or skill performed.

Conclusion

Based on the results of various prior investigations, it can be determined that muscle architecture is an area that should be investigated more in the future. This research will be valuable because it will give a better knowledge of the relationship between muscle architecture and performance, as well as the importance of differentiating muscle fiber on the basis of muscle architectural parameters.

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