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Physiology and Physical Qualities of Taekwondo - Adaptation of training in age over 50

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Content

1. Introduction

The idea for this dan thesis originated from discussions with other taekwondo practitioners and instructors. We reflected on our own functional abilities and how we can no longer perform the same way as when we were younger, even though we may still want to. Additionally, for many of our instructors, there are older individuals among the practitioners, and considering their needs has become increasingly important over the years. Many of these practitioner's face challenges due to normal aging, such as injuries, but in this thesis, I decided to focus only on the physical aspects of the sport and how they change with aging. I also wanted to explore how these physical characteristics manifest in taekwondo.

Generally, most sport analyses are conducted from the perspective of competitive sports, focusing on how to achieve success in competitions. Taekwondo matches, as part of the Olympics, are the most visible aspect of the sport and likely its most well-known form of competition. In recent years, the number of competitors in poomsae (poomsae) has increased significantly, and more practitioners are focusing on this discipline. However, the majority of taekwondo practitioners "only" practice recreationally. Even so, most of them likely train with specific goals, such as preparing for a dan test. In this thesis, I wanted to highlight the perspective of non-competitive practitioners, especially regarding physical characteristics, as self-defence training plays a significant role for many aiming for black belt tests.

I do not wish to diminish the mental demands of the sport or the psychological well-being that taekwondo brings, but I feel that addressing this aspect in my work would have been incomplete at this stage, and the mental side of the sport undoubtedly deserves its own focus. Taekwondo has been my hobby for nearly 30 years and my profession for over 20 years, so I feel I have gained a lot from the sport, both physically and mentally.

I hope this work helps taekwondo instructors, coaches, and teachers better understand the physical qualities underlying the techniques of the sport and how to develop them, as well as how to plan training for individuals over the age of 50. Additionally, I hope that every practitioner over 50 who reads this will gain a better understanding of their body and its changes with aging, and that they may treat themselves and their bodies more gently.

2. What is Taekwondo?

Taekwondo is a martial art originating from Korea. In Finland, Taekwondo has been practiced since the late 1970s, when Grandmaster Dae Jin Hwang introduced the sport to the country. The main components of Taekwondo are patterns (poomsae), kyorugi, breaking, and self-defence. (Finnish Taekwondo Federation, 2024)

The Finnish Taekwondo Federation has 71 member clubs. The northernmost member club is in Iisalmi, and most clubs are located in Southern Finland. Altogether, the member clubs have over 9,400 practitioners. Among these, approximately 1,300 hold a license from the Taekwondo Federation. A license is mandatory for participation in federation events (such as camps, training courses, competitions, etc.). (Finnish Taekwondo Federation, 2024)

Training in clubs typically focuses on teaching the basic techniques of Taekwondo and their application. The basic techniques of Taekwondo include various kicks and hand techniques, which are used in combinations in patterns and step sparring, as well as applied in kyorugi and self-defence.

2.1. Taekwondo Competition Formats

Taekwondo features two main competition formats: sparring (kyorugi), which is contested up to the Olympic level, and patterns (poomsae), which are competed up to the World Championship level. Additionally, there are breaking competitions, which currently do not hold national championship status, but efforts are being made to develop this area. Only a small portion of Taekwondo practitioners in Finland participate in competitions.

Kyorugi in Taekwondo has undergone significant development in the 2000s through rule changes aimed at advancing it toward elite sports. Electronic chest protectors and the introduction of higher points for head kicks and spinning kicks have diversified the sport and influenced kyorugi training practices.

Similarly, poomsae competitions have seen rapid development, and their popularity in Finland has been steadily increasing. Currently, there are more poomsae competitors than kyorugi competitors in Finland.

2.2. Taekwondo Sparring (Kyorugi)

In Taekwondo kyorugi, the goal is to defeat the opponent by scoring more points. Under current rules, the winner is determined by the number of rounds won. Each round starts at a score of 0-0, and the competitor with the higher score at the end of the round wins that round. Winning two out of three

rounds is sufficient to win the match. A round lasts two minutes, with a one-minute break between rounds.

Points are scored for kicks to the chest protector or head and for punches to the chest protector as follows:

Figure 1. Techniques that Award Points in Taekwondo Kyorugi

The valid points are as follows.
3.1 One (1) point for a valid punch to the trunk protector
3.2 Two (2) points for a valid kick to the trunk protector
3.3 Four (4) points for a valid turning kick to the trunk protector
3.4 Three (3) points for a valid kick to the head
3.5 Five (5) points for a valid turning kick to the head
3.6 One (1) point awarded for every one "Gam-jeom" given to the opponent contestant

(World Taekwondo, Competition rules and interpretation, 2024)

In kyorugi, competitors use electronic chest protectors, headgear, and foot protectors. The chest protector and headgear detect scoring hits through sensors in the competitors' socks. Additionally, techniques targeting the chest protector must have sufficient power to score points. The required power level varies by weight class, with lower thresholds for lighter weight categories and higher thresholds for heavier ones.

"Gam-jeom" refers to a penalty point, which awards one point to the opponent. Penalty points can be given for actions such as stepping out of the competition area, falling, avoiding or delaying the match, grabbing, kicking below the waist, attacking after the referee has stopped the match, and so on.

In kyorugi, competitors are divided into categories based on age, gender, skill level, and weight. There are separate divisions for recreational athletes and ranking competitors. Ranking divisions begin with the cadet category for athletes aged 12–14.

2.3. Patterns Competition (Poomsae)

In poomsae competitions, competitors perform predetermined sequences of movements, known as poomsae. The required poomsae are determined by the competitor's age group, and specific poomsae are selected randomly for each round (preliminary, semifinal, and final), with two poomsae performed per round. Competitors perform two poomsae with a short break in between.

Judges evaluate the performance from two perspectives: Accuracy and Presentation. Scores are divided into Accuracy points (4.0) and Presentation points (6.0). Accuracy points are deducted for mistakes, while Presentation points are evaluated based on the overall quality of the performance.

Figure 2. Scoring criteria in poomsae competitions (World Taekwondo, Competition rules of Poomsae, 2024)

채점항목 Scoring Criteria	세부 기준 항목 Details of Scoring Criteria	점수 Point
정확성 (4.0) Accuracy (4.0)	기본동작 정확성 Accuracy in basic movement	4.0
	품새 별 동작의 정확성 Accuracy in individual movement of the Poomsae	
	균형 Balance	
연출성 (6.0) Presentation (6.0)	속도와 힘 Speed and power	2.0
	강유-완급-리듬 Rhythm & tempo	2.0
	기의 표현 Expression of energy	2.0

Accuracy includes precision in basic techniques, accuracy in individual movements within the poomsae, and balance. Presentation evaluates speed and power, rhythm and tempo, and energy expression. The competitor with the highest total score wins the competition.

Poomsae competitions are held in individual, pair, and group categories. Competitors are divided into categories based on age, gender, and skill level. A competitor can participate in multiple categories within the same competition, for example, in the individual category as well as in pairs and groups.

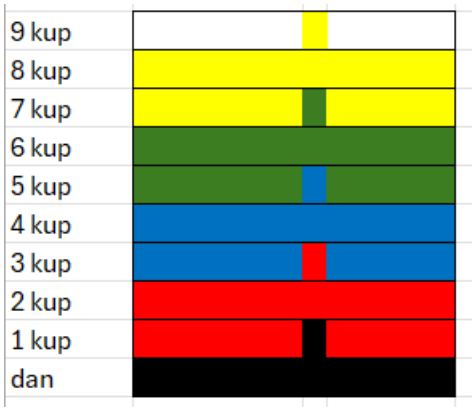
In addition to the predetermined poomsae, there is a freestyle category. In freestyle competitions, participants—whether individuals, pairs, or groups—perform a self-designed sequence to music, incorporating Taekwondo techniques. Mandatory elements include moves such as a jumping side kick, multiple kicks during a single jump, and other advanced techniques.

2.4. Progression in Taekwondo

In Taekwondo, as in many other Eastern martial arts, there is a belt rank system. Beginners start with a white belt and typically earn the yellow belt, or 8th kup rank, at the end of a beginner or basic course. Each coloured belt has two levels, so after passing the yellow belt test, the next rank is the second-level yellow belt, or 7th kup. Progression continues through green, blue, and red belts before reaching black. (See figure 3.)

Achieving a black belt typically requires 5–6 years of dedicated practice, though it often takes longer.

Figure 3. The Most Commonly Used Coloured Belt Ranks in Taekwondo in Finland



Dan ranks are typically divided into three categories:

1st–3rd Dan: Kyosanim (instructor ranks)

4th–6th Dan: Sabumnim (teacher ranks)

7th–9th Dan: Kwanjangnim (master ranks)

Progression through the black belt ranks follows the same principle as colored belts, requiring a belt test (dan test). Typically, there is a two-year gap between tests for 1st and 2nd Dan, a three-year gap between 2nd and 3rd Dan, and so on. Depending on the teacher, advancing through the black belt ranks may also require attending instructor and coaching courses, as well as gaining practical experience in teaching or coaching.

Compared to many other martial arts, Taekwondo differs in that advancement in black belt ranks is achieved only through a belt test. In some other martial arts, achievements such as competition success or contributions to the development of the art (e.g., work at the club or federation level) may suffice for promotion to a higher rank.

2.5. Domains of Taekwondo

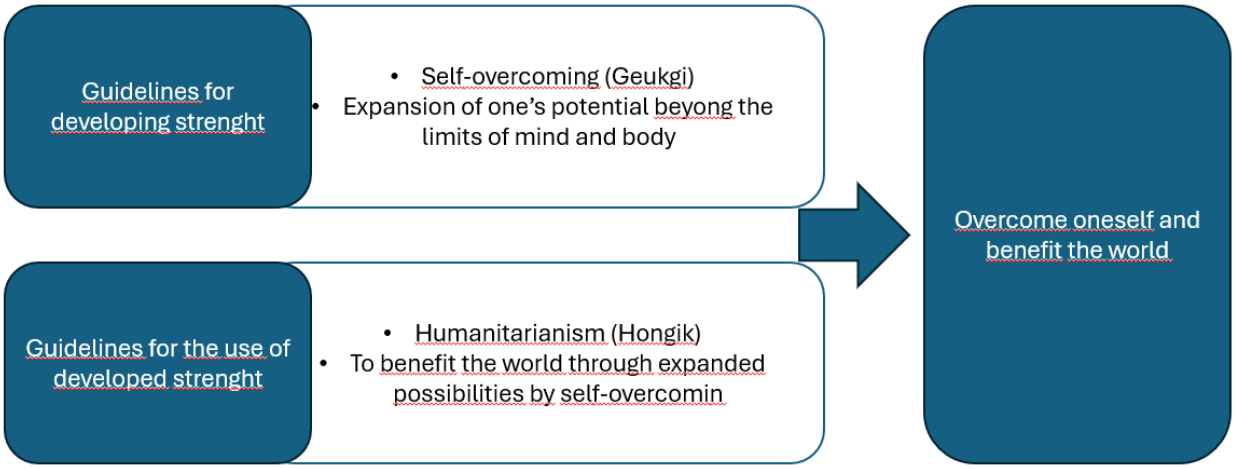
Taekwondo is a traditional Korean martial art that originated from combat techniques, and has become a sport that aims at the harmonious development of the mind and body, and a competition sport that involves the use of strength and tactics under fair conditions. Taekwondo is widely practiced both as a form of mind-body exercise that emphasizes the mental development of practitioners and as a bare-handed self-defence technique.

Taekwondo is a culture. All cultures consist of three domains: the image of a desirable human, the means of change to become such a desirable human being, and activities to induce such changes using such means. The three areas of Taekwondo are the Taekwondo spirit, Taekwondo techniques,

and Taekwondo practice. Taekwondo spirit is an area associated with the image of a desirable human the practitioners aim to pursue through Taekwondo. (Taekwondo Textbook, Kukkiwon)

The spirit of Taekwondo is a guideline related to the development of strength, and at the same time, to the utilization of the developed strength. These two processes, which develop independently of each other, are interconnected through the spirit of Taekwondo. These two guidelines (to developing strength and to the use of the developed power) naturally combine with each other in Taekwondo practice. Taekwondo practitioners develop their strength through repeated experiences of self-overcoming, and in the process, they grow into a bigger self.

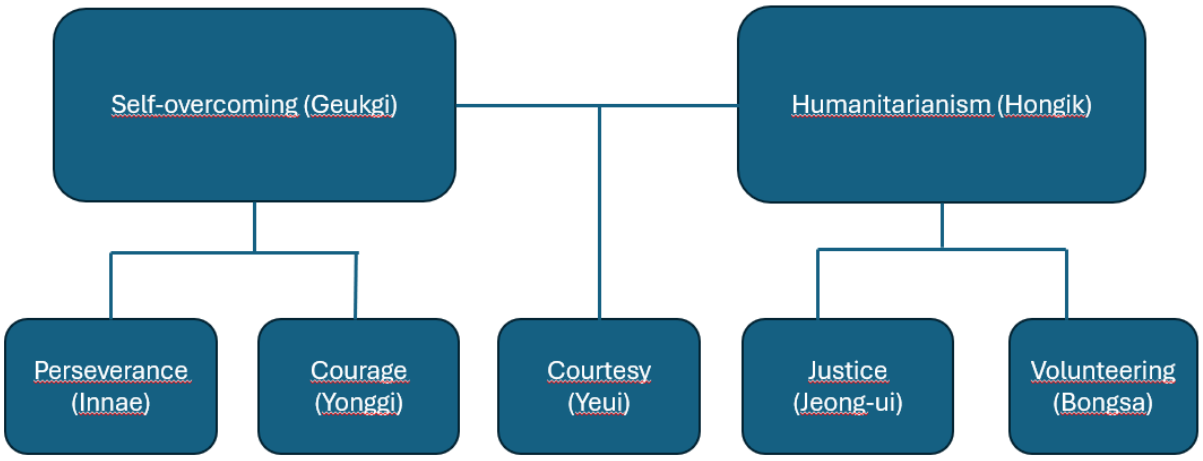
Figure 4. Meaning of the spirit of Taekwondo, Kukkiwon



Meaning of the spirit of Taekwondo
(International Taekwondo Master Course Textbook, Kukkiwon)

Taekwondo spirit is a totality of values that practitioners, masters, and Taekwondo-related organizations like Kukkiwon, WT and Taekwondo itself should ultimately aim to achieve. The five virtues of Taekwondo are guidelines for actions to practice self-overcoming and humanitarianism in everyday life. The five virtues are perseverance (Innae), courage (Yonggi), courtesy (Yeui), justice (Jeong-ui) and volunteering (Bongsa).
(Taekwondo Textbook 1, Kukkiwon)

Figure 5. Relations between Taekwondo Spirit and The Five Virtues of Taekwondo, Kukkiwon



Relations between Taekwondo spirit and the Five Virtues of Taekwondo
Taekwondo Textbook 1, Kukkiwon

The Taekwondo spirit and its development are as important as, or even more important than, physical training and skill development. In terms of psychological demands, goal setting, striving to achieve those goals, and committing to long-term effort become significant.

However, this written work focuses on the development of physical qualities and how they change with aging.

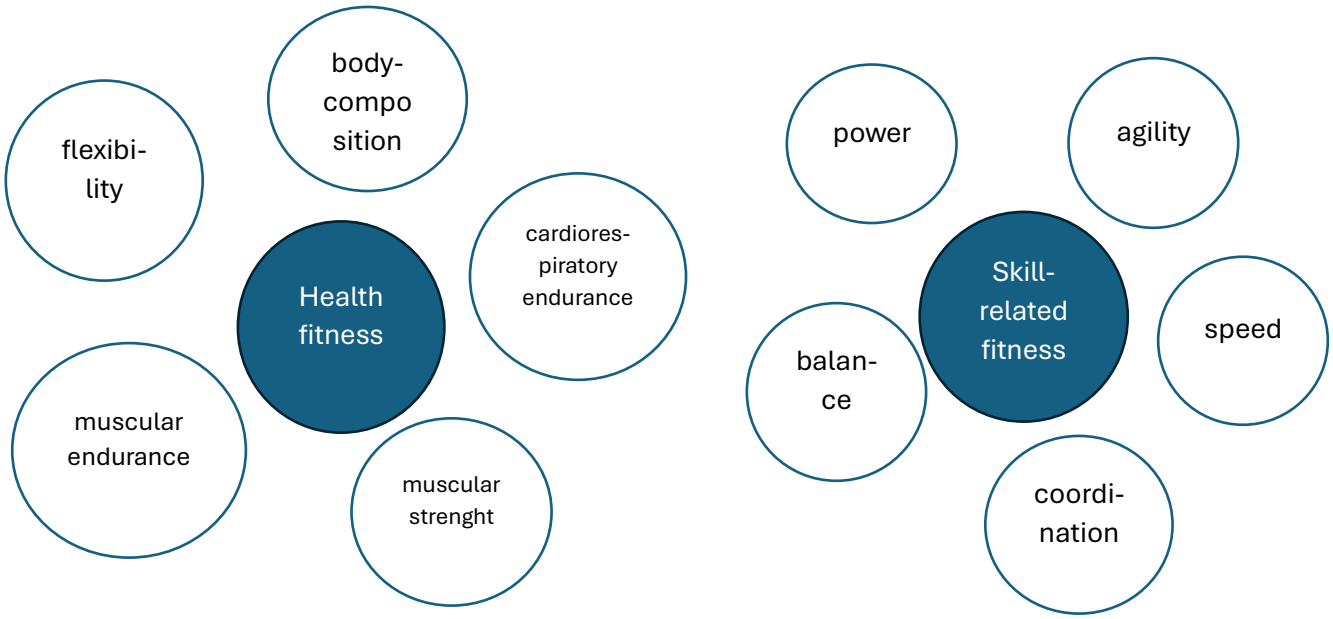
3. Sports analysis of Taekwondo

3.1. Physical Qualities in General and in Taekwondo Competitions

Physical activity requires a variety of physical qualities, which form the foundation upon which technical skills are built. Sufficient physical capabilities are essential for performing daily tasks and maintaining good health. The primary physical qualities are speed, strength, endurance, and flexibility.

When practicing Taekwondo, a person needs certain level of fitness. In Taekwondo, fitness refers to the psysical ability a person needs to perform Taekwondo skills, and it comprises two elements: health fitness and exercise fitness. Health-related fitness includes factors that lead to healthy lives, skill-related fitness includes factors that perform exercise skills effectively. (Taekwondo Textbook 1, Kukkiwon)

Figure 6. Health-related fitness and skill-related fitness (Taekwondo Textbook 1, Kukkiwon)



For Taekwondo, key performance factors include agility, the neuromuscular system's ability to produce quick, coordinated movements in response to directional changes, and explosive speed, the ability to execute a single technique with power and precision. (Temonen T. 2009, p. 7)

Different physical qualities are emphasized in Taekwondo kyorugi, poomsae, and non-competitive training. Overall, the sport requires speed, strength, endurance, and flexibility. Technical skill is always critical, but several types of speed, for instance, are prioritized in kyorugi and poomsae.

In Taekwondo kyorugi, the winner is the competitor who scores more points with kicks and punches. Several types of kicks are used, including straight kicks and spinning kicks executed through the back. Spinning kicks and head kicks yield more points than straight kicks to the body. Generally, kicks score higher than punches (e.g., one point for a sufficiently strong punch, at least two points for a kick).

To outscore an opponent, a competitor must land more scoring techniques while avoiding the opponent's attacks. Kyorugi requires several types of speed, strength, and flexibility. Endurance is also crucial, as a match consists of three 2-minute rounds. A competitor may have multiple matches in a single day, each requiring warm-ups and exercises to activate the nervous system, such as reaction drills.

In poomsae competitions, participants perform predetermined sequences of techniques lasting between 0.5 and 1.5 minutes, depending on the inclusion of slow movements. Judges score performances by deducting points for errors, dividing scores into accuracy and presentation categories.

Poomsaes involve techniques such as blocks, punches, strikes, kicks, and special techniques, executed from Taekwondo stances and in motion. For hand techniques, precision in execution height is crucial. For example, straight punches (jirugi) are targeted to the sternum height (momtong jirugi) or under the nose (olgul jirugi), as specified.

A notable exception applies to kicks. In ranking categories, all kicks (with one exception) must reach at least chin height, while in recreational categories, they must reach at least waist height. If the kicks fall below these thresholds, judges deduct points.

3.1.1. Speed

Speed is defined as the distance covered within a specific period of time, inherently assuming direction. Its manifestation varies across different sports. For example, in running, maximal linear speed is measured, whereas in team sports, speed involves considerations such as equipment and opponents, and an individual's absolute maximum speed is only achieved momentarily. Nevertheless, a high level of speed is advantageous even in these sports.

Speed is one of the most challenging physical qualities to develop. It was previously thought to be largely inherited, but it is now understood that speed and its components can be improved, despite the inherent difficulties.

Speed is categorized into five main types: basic speed, reaction speed, explosive speed, movement or locomotor speed, and speed agility. The types of speed and their definitions are outlined in Table 1.

Speed is heavily dependent on the functioning of the nervous system, muscle fiber contraction capability, and energy metabolism. Muscles must be capable of generating energy anaerobically, especially from immediate energy sources. Multiple factors influence speed qualities, particularly sport-specific speed, and these can be targeted through training. Such factors include reaction ability, rhythm sense, movement frequency, speed strength, skill, flexibility, elasticity, and relaxation.

Table 1. Types of Speed and Their Definitions (Hakkarainen et al., 2009)

Type of Speed	Definition
Basic Speed	The general ability of the neuromuscular system to function quickly. It is not a sport-specific attribute and is often thought to be hereditary, acquired through childhood play, and poomsae the foundation for training sport-specific speed.
Reaction Speed	Reaction speed is measured by reaction time, which refers to the time it takes from the stimulus to the initiation of movement. For example, in a sprint start, it is the time taken from the starting gun to the initiation of force production.
Explosive Speed	A single, as fast as possible, movement execution. For example, a spike in volleyball, a slap shot in ice hockey, a jump takeoff in jumping events, etc.
Movement or Locomotor Speed	Movement speed refers to a cyclical, or as fast as possible, repeated execution of a movement. For example, skating speed, running speed, swimming speed, etc.
Speed Agility	The ability of the neuromuscular system to function quickly and purposefully in skillful movements. For example, in ball sports, speed agility is a crucial attribute because the individual must be able to control the equipment, the opponent, and the tactics during fast-paced gameplay.

3.1.1.1. Speed in Taekwondo

In kyorugi training, basic speed is the foundation upon which sport-specific skills can be built. When considering competition, speed agility, reaction speed, and explosive speed are all important qualities. For executing a single kick technique, reaction and explosive speed are the most crucial, while in an attack (where a kick or multiple kicks are performed, the opponent's techniques are avoided, and the proper distance is maintained in relation to the opponent), speed agility is the most

important type of speed. This allows for fast movement and technique execution while managing distance and reacting to the opponent's movements.

In poomsae competitions, basic speed is an essential attribute upon which speed agility can be developed as the athlete’s skill level increases. The competitor must be able to perform the techniques correctly (accuracy), but also quickly and powerfully (presentation). Among the types of speed, explosive speed is particularly emphasized for individual techniques. However, when considering the entire poomsae, speed agility becomes the dominant type of speed. The competitor must be able to perform the pre-determined sequence of techniques correctly (in the right order, direction, and height) quickly, explosively, and in a specific rhythm. Some techniques in poomsae are performed slowly (5-8 seconds), and there are pauses between movements, so the performance is partially interval-based. Another component of poomsae performance and speed is rhythm sense.

3.1.2. Strength

Strength is the foundation of all movement and sports activities, as without sufficient strength, movement cannot be produced. Several structural and functional factors influence strength production: 1) muscle fiber size, 2) muscle fiber composition, 3) the motor nervous system’s ability to activate and regulate muscle contraction, 4) the ability of muscles and proprioceptive senses to inform the central nervous system, 5) the elasticity of muscle support structures and tendons, 6) the length ratios of lever arms (bone length and tendon attachment points), 7) muscle metabolic factors, 8) various hormonal regulatory factors, 9) training, 10) gender, and 11) age.

Strength training aims to improve the essential strength production required for the sport. However, without sufficient base strength, progress is limited. Strength training should be a long-term and varied process, where different strength qualities are trained at optimal stages. To simplify programming, types of strength are categorized into three main groups: maximal strength, endurance strength, and explosive strength.

Maximal strength is divided into: a) neural and b) hypertrophic,
Endurance strength is divided into: a) muscular endurance, b) strength endurance,
Explosive strength is divided into: a) power strength and b) explosive power.
(Hakkarainen et al., 2009)

3.1.2.1. Strength in Taekwondo

In Taekwondo, strength qualities most relevant to kyorugi emphasize explosive strength within the broader category of speed strength. Plyometric power is especially important, and power strength is also needed, so training for overall speed strength is beneficial for kyorugi. It's important to note that

training for explosive strength will also lead to some development of maximal strength, so from a sport-specific perspective, focusing on maximal strength training may not always be the most effective approach.

From the endurance strength category, strength endurance, which develops the muscle's anaerobic power output and local lactate removal mechanisms, is particularly important.

In poomsae competition, the most important strength qualities are speed strength, particularly explosive power. When considering the entire performance of a poomsae, power strength also plays a crucial role. A poomsae competitor should have a solid base level of strength that allows for the development of speed-strength qualities. As mentioned earlier in the context of kyorugi, training for explosive strength will also improve maximal strength, making isolated maximal strength training unnecessary for the specific needs of the sport. In terms of endurance strength, it is beneficial to enhance the muscle's aerobic and anaerobic energy production as well as local muscular endurance factors, which can be improved through muscular endurance training.

3.1.3. Endurance

General physical fitness plays a significant role in all movement and sports training. A durable foundation in endurance and muscular fitness is essential. Endurance fitness is reflected in the body's ability to resist fatigue, transport oxygen, and use it to produce the energy needed for muscular work. Good endurance fitness helps the body deliver the necessary amount of oxygen and energy to the tissues and efficiently handle physical stress. (Hakkarainen et al., 2009, p. 285)

Endurance training is crucial for improving basic fitness. When large muscle groups are subjected to prolonged strain, the load primarily affects the respiratory and cardiovascular systems, as well as the metabolism of the working muscles. This process develops endurance at two levels: improving the function of the respiratory and cardiovascular systems and enhancing the oxygen and energy utilization of the tissues (muscles). Endurance training also influences hormones that regulate the metabolism of carbohydrates and fats, as well as fat tissue and the nervous system. (Hakkarainen et al., 2009)

Endurance is divided into categories based on the heart rate zone in which it is trained. To improve endurance, it is necessary to train consistently over months and even years. The primary focus in training should be on basic endurance, as only with an adequate level of basic endurance can effective speed endurance and maximal endurance exercises be performed. The table does not include speed endurance, which is built on other physical qualities. Speed endurance training requires good endurance and speed characteristics. Strong speed also demands sufficient strength, meaning

that developing speed endurance requires training all physical qualities. Speed endurance is usually developed through sport-specific training. Therefore, mastering and optimizing sport technique is crucial for its development.

3.1.3.1. Endurance in Taekwondo

In terms of endurance, sufficient basic endurance is crucial for developing sport-specific skill in training. During kyorugi, athletes operate at the boundaries of maximum and speed endurance. However, a match is interval-based, with intense effort lasting only a few seconds at a time. The recovery period cannot be strictly defined, as it depends on the opponent and their tactics. During a two-minute round, effort exceeds the anaerobic threshold, which results in lactic acid accumulation that slows down movement unless the muscles can break it down quickly. Good speed and maximum endurance raise the anaerobic threshold, thus helping to endure short bursts of intensity without fatigue caused by lactic acid buildup.

For a poomsae competitor, endurance is more focused on basic endurance and general muscular fitness. The form performances are short (0.5 to 1.5 minutes), with brief pauses in between, allowing the muscles to recover partially, so maximal oxygen uptake is not necessary. Poomsae are performed back-to-back, with less than a minute's rest in between. Speed endurance training can help develop aerobic energy production and carbohydrate metabolism, making it beneficial for performing both form routines without muscle fatigue. As in kyorugi, speed endurance plays a crucial role in poomsae as well. The best way to develop speed endurance is through sport-specific training, in this case, form practice.

3.1.4. Flexibility

Flexibility, or suppleness, refers to the range of motion of the body's joints. Flexibility plays a significant role in both sports and daily life. While it is partially hereditary, it can be influenced by training. Flexibility can also be considered a motor skill, meaning the ability to achieve the required range of motion for a specific movement. Flexibility is also influenced by structural factors (joint range of motion), factors related to force production, and coordination. (Hakkarainen et al., 2009)

Flexibility can be divided into active, passive, and anatomical flexibility. Active flexibility refers to the range of motion that is achieved through one's own muscle work. Passive flexibility refers to the range of motion achieved through an external force (e.g., gravity, the inertia of a swinging body part, muscle force from another person, or any other external force). Passive flexibility is always greater than active flexibility. Anatomical flexibility is a theoretical concept and refers to the range of motion of the joints when the muscles are removed. This range is always greater than both active and passive flexibility.

Flexibility can be improved through stretching and mobility exercises. Training methods are typically categorized based on whether the force is active or passive and whether the movement is dynamic or static. In active methods, the moving force is the antagonist (the opposing muscle) of the muscle being stretched, while in passive methods, external forces such as gravity or a partner are used. Dynamic stretching involves rhythmic and pulsing movements, while static stretching holds the joint in a stretched position with the help of antagonistic muscles, allowing for a longer duration of stretch.

Examples of other exercises aimed at improving flexibility include PNF stretching (PNF = proprioceptive neuromuscular facilitation) or JRV stretching (in Finland, JRV stands for tension-relaxation-stretch). These methods involve both the contraction and relaxation of the agonist and antagonist muscles, along with static stretching to increase range of motion. There is minor difference in effectiveness between these techniques, and the effectiveness of training depends on the starting condition, age, and specific goals set. (Hakkarainen et al., 2009)

3.1.4.1. Flexibility in Taekwondo

Flexibility, particularly active flexibility in the lower limbs, is an important attribute in taekwondo competition. As previously mentioned, more points are awarded for head kicks than for body strikes, and kicks score higher than punches (head strikes are not allowed). Lifting the leg to the head requires good flexibility, speed, strength, and technical skill to ensure the kick is directed correctly and lands at the proper point on the foot, meaning with control. Good flexibility should be maintained and improved throughout an athlete's career, and this can be trained through both active mobility exercises and passive stretches.

Flexibility is also an important attribute for those competing in poomsae (poomsae) competitions. As mentioned earlier, in ranking poomsae, kicks must reach at least head height (the point of impact should be at or below the chin), and if the height is lower, judges will deduct points. Unlike in kyorugi, upper body flexibility also plays a role in poomsae. In the presentation scoring, judges evaluate the strength and speed of the performance, rhythm, tempo, and expression of energy. If the flexibility in the upper body is poor, power generation suffers, which can lower the score. However, active flexibility in the lower limbs is of even greater importance for both the height of kicks and their power and speed. Flexibility should be actively trained throughout an athlete's career using both active mobility exercises and passive stretches.

3.1.5. Physical Qualities in Non-Competition-Oriented Training

Non-competition-oriented training can be considered more versatile compared to training aimed at a specific competitive format. As previously mentioned, the majority of Taekwondo practitioners do not compete but train with goals such as preparing for belt tests, improving personal fitness, or developing and maintaining other physical qualities. Many may also aim to learn self-defence skills. However, in practice, competitive athletes generally engage in more training, both in terms of quantity and frequency, while recreational practitioners usually train one or two times a week, and the quality of their training may not be the same and cannot replace the quantity in this case.

Developing physical qualities requires planning and consistency. Competitive training usually incorporates planning and progressive progression, but this is often not the case with recreational practitioners. In many clubs, the focus is placed on teaching martial arts techniques to practitioners, rather than understanding how to develop the physical qualities required for those skills through training other than technique-based exercises.

In all Taekwondo training, it is important to have an adequate level of physical fitness to perform techniques correctly. Sufficient basic fitness (muscular fitness) is needed to complete training without fatigue, along with enough strength, speed, and mobility to perform techniques correctly without injury or the risk of overuse injuries.

Basic technique training and poomsae practice in Taekwondo can be linked to the same physical qualities as those needed in competitive poomsae. Speed skills, and especially the nervous system's ability to produce techniques quickly, are also important for recreational practitioners since techniques are often performed in combinations. Both basic techniques and poomsae are based on the idea of fighting an invisible opponent, and in this context, the speed and sharpness of the movements are also crucial from the recreational practitioner's perspective. Good basic endurance and sufficient muscular fitness help improve performance and allow techniques to be performed effectively. However, to increase the speed and fluidity of basic movements, attention should be paid to speed training and developing speed with the proper intensity and sufficiently simple techniques to allow for improvement. Speed training should be performed frequently and for short durations to prevent the nervous system and muscles from becoming fatigued.

Step kyorugi and self-defence exercises can be compared more closely to kyorugi and kyorugi training. Both step kyorugi and self-defence involve a responding opponent. In step kyorugi, the form is more formal, with predefined stances for the attacker and defender, and attacks are executed in a specified manner. In self-defence, a wider variety of steps and techniques can be used and applied. However, the key factor in self-defence is the stimulus provided by the attacker, to which the defender reacts

and responds. In this case, reaction time is an important attribute, allowing the defender to protect themselves from attack without getting hit in both practice formats.

3.2. Motor Skills

Motor skills refer to the ability that requires voluntary movement of the body and/or limbs to achieve a goal, and it always includes a target that is being aimed for. The definition of motor skills also involves the requirement of bodily or limb movements to achieve the goal. Motor skills are learned, meaning they are not reflexes or otherwise involuntary actions.

(Jaakkola T., 2010, p. 45-46)

Motor skills are classified according to different frameworks. They can be classified based on whether large or small muscle groups are required for their execution. This distinction is called gross motor skills and fine motor skills. Gross motor skills refer to basic motor skills such as walking, running, jumping, and throwing. Fine motor skills, on the other hand, require eye-hand coordination, precision, and dexterity, such as in throwing darts, writing, and precision throwing. These skills can be seen as a continuum, with gross motor skills on one end and fine motor skills on the other.

Motor skills can also be categorized based on the environment in which they are performed. The environment may be either constant or changing, and based on this, the skill can be referred to as either closed motor skill or open motor skill. An example of a closed motor skill is high jumping, where the environment remains the same for each attempt. The performance area is always the same, although weather conditions or psychological states may vary. If the skill is performed in an unstable environment that changes during or between performances, it is considered an open motor skill. Some skills can be classified as either closed or open. For example, running on a track is a closed skill, while cross-country running is an open skill, as the surface changes and the track has hills, dips, and slopes. In closed skills, the performer's attention is focused internally on the body, whereas in open skills, attention must be directed to the changing environment.

A third way to classify motor skills is based on whether the skill is discrete, serial, or continuous. Discrete skills involve a single, distinct movement with a clear beginning and end. Examples include jumping upwards, a shooter's shot, or catching a ball. Serial skills involve two or more discrete skills performed together, such as in dance or specific step sequences. A continuous motor skill involves repetitive action where the same technique is repeated over a long period, such as running or swimming.

Motor skills can also be classified based on whether they are performed alone or with others. If the skill is performed individually and in isolation, it is referred to as an individual skill. Examples include

figure skating, the triple jump, or individual aerobic competitions. Skills can also be performed simultaneously with others but without continuous interaction or contact. Examples of such skills are swimming or triathlon. Interactive skills are performed together with and in cooperation with others, such as in team ball games. This classification also takes into account whether the execution and timing are under the control of the performer or someone else. (Jaakkola T., 2010)

Perceptual-motor skills and their development refer to abilities through which individuals perceive and understand their own body and its parts in relation to the surrounding space, time, and force. Perceptual-motor skills are largely automated and unconscious. Components of perceptual-motor skills include body awareness, spatial awareness, and the perception of direction and time. Body awareness refers to information about the location and names of different body parts, their relationships with each other, their importance for various functions, and how the body and its parts are moved efficiently or relaxed. Spatial awareness involves perceiving objects and things in relation to oneself and is necessary when assessing how much space the body requires in relation to the environment. Direction awareness refers to the development of spatial awareness and the ability to move effectively through space, as well as understanding the dimensions of the environment and the concepts of left and right. Time awareness involves the control of rhythm, simultaneity, and order. A good example of this is a dance or other sequence of movements performed in a specific rhythm and order. (Jaakkola T., 2010)

Body control can broadly be understood as all types of movement, constituting versatile motor skillfulness – there is no movement without body control. It can be defined as smooth movement involving balance and movement control, which impacts speed, force, rhythm, and aesthetics. On the other hand, even remaining in a static position may require body control. (Kalaja S. & T., 2022)

Balance ability can be of two types: static and dynamic. Balance ability refers to the skill of maintaining, correcting, or restoring one's body balance during different movements and postures. Static balance is needed for maintaining or correcting balance in stationary positions or slow movements. Dynamic balance, on the other hand, is the ability to maintain balance while in motion. Static balance is primarily maintained through the inner ear's balance system and visual perception. In dynamic balance, the ability to sense the accelerating movement of the body becomes crucial. Balance is a very central and key factor in all movement. (Hirtz, 1988)

3.2.1. Motor Skills in Taekwondo

Taekwondo techniques involve both gross motor skills and fine motor skills. Large muscle groups are used in techniques like kicks, but these kicks also contain elements requiring fine motor skills, such as toe positioning in a front kick, wrist rotation in hand techniques, etc. Practically speaking, beginners

rely more on gross motor skills, and as training progresses, fine motor skills are increasingly incorporated. At the beginning, techniques are practiced as closed skills, meaning they are always the same and unchanging. However, as skills develop, they are applied in contexts such as kyorugi, step patterns, or self-defence. In this case, they become open skills, because the performer's focus shifts from the technique itself to the opponent and their movements.

Similarly, the martial arts skills in taekwondo can initially be seen as discrete skills, where individual techniques and their movements are practiced. As skills improve, they evolve into serial skills, where different techniques are combined into combinations or patterns. Poomsae or pattern competitions, or practicing poomsae alone, can also be considered individual skills, while kyorugi and self-defence are interactive skills.

Although taekwondo is fundamentally an individual sport and techniques are performed individually, in practice, training is almost always done in a group. Kyorugi with an opponent is a major part of training, and self-defence skills cannot be practiced alone, so interactive skills are also required.

Body control and balance are essential skills in taekwondo, without which it is difficult or even impossible to control and perform techniques. Movement in taekwondo is crucial, and even in stationary techniques, good body control and balance are necessary. In kicks, balance is a critical factor for the execution to be possible at all (except for applied techniques, such as sitting). Both competitive formats require good balance. In kyorugi, movements are fast and involve many direction changes and shifts in body weight while executing kicks, thus the need for dynamic balance is greatest. In poomsae, balance is important not only when performing kicks while standing on one leg, but also in spinning movements (e.g., in the Keumgang form) and in slow techniques where one stands on one leg. In these cases, balance is static.

4. Physiological Changes with Aging

The human body undergoes various changes throughout life, particularly after middle age. These changes affect different organ systems and can be observed both externally and internally. Such aging phenomena include, among others, a reduction in height, muscle weakening, changes in bone structure, deterioration of sensory functions, and changes in heart function.

A person's height begins to decrease on average after the age of 40, and this process accelerates starting from the age of 60. On average, height may reduce by about 2 cm every 10 years, which is caused by several factors. One of the most significant factors is the dehydration of the intervertebral discs and the reduction in their height. Additionally, bone mineral density decreases, and bone mass weakens, which increases the risk of fractures and osteoporosis.

The body starts to store more fat around middle age, particularly around the waist and abdomen, leading to changes in the body's fat profile. This is partly due to hormonal changes, such as the decrease in estrogen and testosterone. The increase in fat storage can lead to numerous health issues, including cardiovascular diseases, diabetes, and joint problems.

Muscle performance is at its best in the 20-30 age range, but after this, muscle mass and strength gradually decrease. Muscle weakening, also known as sarcopenia, begins in early adulthood but becomes more pronounced after the age of 40. This weakening affects both muscle mass and the muscles' ability to generate force and endurance. At the same time, muscles' ability to recover decreases, which can lead to reduced mobility and balance issues.

Bone density begins to decrease from around the age of 40. This is due to the weakening of the balance between bone formation and resorption. Women are particularly vulnerable to osteoporosis after menopause, but men also experience bone weakening as they age. The reduction in bone density makes bones more fragile and susceptible to fractures.

The cartilage surfaces of the joints wear down with age, which can lead to the development of osteoarthritis. The amount of joint fluid decreases, which in turn affects the joints' mobility and can cause pain and stiffness. Additionally, ligaments and tendons become less flexible and more brittle, increasing the risk of sprains and strains. These changes can impair mobility and cause pain, especially in joints such as the knees, hips, and spine.

As people age, many sensory functions, such as vision, hearing, and the sense of balance, deteriorate. Vision impairment is one of the first and most noticeable changes that come with age. The eye lens

hardens and becomes less flexible, making it more difficult to focus on near objects. Additionally, the sensitivity of the retina decreases, which reduces contrast sensitivity and night vision.

The function of the balance system in the inner ear also declines with age, which can cause a deterioration in balance and coordination. One cause of balance disturbances could be the aging processes in the inner ear, which affect hearing and may predispose individuals to falls.

The sense of position and movement, known as proprioception, can also weaken, reducing the body's ability to perceive its position and movements. This can make it more difficult to move on uneven surfaces or to perform movements quickly.

Touch and position sense can also diminish, making it harder for people to accurately perceive obstacles in their environment or the position of their body, which can increase the risk of falling.

Memory and cognitive functions typically begin to decline around the ages of 50-60, although individual differences are considerable. Memory decline may be minimal and particularly noticeable in short-term memory, such as remembering new things or the speed of recall. The brain’s plasticity decreases with age, but cognitive activities and intellectual stimulation can slow down the progression of this process.

However, memory decline is not an inevitable part of aging. Healthy lifestyle choices, such as adequate sleep, exercise, nutrition, and brain activity stimulation, can significantly slow the decline of cognitive functions.

Respiratory function declines with age, as the elasticity of lung tissue decreases, and the number of alveoli reduces. This can affect respiratory capacity and the amount of oxygenated blood. With age, the lungs’ ability to eliminate harmful substances also declines, making older adults more susceptible to respiratory infections.

The maximum heart rate decreases, and the heart muscle’s contraction ability weakens with age. This means the heart cannot pump blood as efficiently as it could in younger years, which may affect physical performance and recovery from exertion. Additionally, the heart’s stroke volume decreases, which can partly impact circulation efficiency.

4.1. Changes in Physical Qualities with Age

Muscle strength in humans declines with age in many ways, and this is particularly noticeable after the age of 30. Muscle strength and power do not remain the same throughout life, even though muscle mass appears to remain relatively stable until the age of 50. However, muscle strength, and especially

the ability to generate fast movements, begins to decline after the age of 30, and this decline significantly accelerates after 50.

The reduction in muscle strength and speed is related to the faster atrophy of fast-twitch muscle fibers (type 2 fibers) compared to slow-twitch fibers (type 1 fibers). Fast-twitch muscle fibers are responsible for generating power quickly and intensely, such as in explosive movements or sprints, but these fibers are not as endurance-resistant as slow-twitch fibers, which are more important for endurance activities.

One reason for the decline in muscle power is the reduction in the intrinsic tension of individual muscle fibers as we age. This means that muscle fibers no longer contract as efficiently, and the muscle's ability to produce force decreases. With aging, the sliding speed of actin and myosin, the proteins required for muscle contraction, decreases by up to 25%, which slows down muscle contraction and directly affects muscle power.

After the age of 50, the decrease in muscle mass accelerates, and muscle mass decreases by about 1% per year. The loss of muscle mass is due to both the reduction in the size of muscle fibers and the loss of muscle cells. Fat and connective tissue begin to replace muscle tissue, which reduces the total amount of muscle mass in the body. This decrease in muscle mass is directly linked to the reduction in maximal strength: as muscle mass decreases, the muscles' ability to generate high forces also declines.

Furthermore, muscle strength and power decrease not only due to the reduction in muscle mass, but also due to the weakening of the nervous system and hormonal changes. The nervous system's ability to activate muscles diminishes with age, which slows the speed and power of force production. Hormonal changes, such as the decrease in testosterone and growth hormone levels, can also contribute to the decline in muscle strength and growth.

Particularly, muscle strength plays a greater role in the risk of disability in older adults than aerobic capacity. This is an important consideration because muscle strength is a key factor in daily activities such as sitting, walking, climbing stairs, and maintaining balance. Strength training is one of the best ways to slow down muscle loss and maintain functionality. However, it is important to note that aerobic fitness decreases by about 1% per year after the ages of 20-30, and this decline cannot be completely prevented, even with rigorous training.

The weakening of muscles is also related to changes in the nervous system. The number of nerve cells begins to decrease around the age of 30, and since most nerve cells cannot regenerate, these cells are especially vulnerable to the effects of aging. The reduction in nerve cells and the slowing of the

nervous system's function decrease its ability to activate muscles, which may explain why muscle force production slows down with age. The decreased conduction speed of the nervous system makes muscle activation and coordination slower, which particularly affects muscle speed and strength.

Balance is one of the most key factors in preventing the risk of falls and injuries. As we age, maintaining balance becomes more difficult, and many factors contribute to this, such as muscle weakness, joint wear, and sensory decline. The deterioration of vision and touch senses particularly affects the ability to detect changes in body position and makes it more difficult to move on uneven surfaces.

Muscles, joints, tendons, and ligaments also play a significant role in maintaining balance. They contain receptors that detect changes in body position and movement. With age, the function of these receptors weakens, leading to slower and less accurate reactions to changes in posture and changes in the surface. This can increase the risk of falls, especially when moving on uneven terrain or making sudden movements.

With age, mobility also significantly declines. Many factors can contribute to the loss of mobility, such as skeletal deformities, muscle weakness, shortened tendons, and reduced tissue elasticity. This means that joints do not move as freely as they did when younger, and the range of motion may narrow, limiting daily movements and activities.

As we age, muscle strength, speed, and mobility decrease significantly, which directly affects quality of life. The decrease in muscle mass, the weakening of muscle strength, and the slowing of the nervous system, combined with other physical changes, can lead to an increased risk of falls, reduced functionality, and diminished physical ability. However, strength training and balance exercises can significantly slow the progression of muscle loss and improve quality of life.

5. Physical Training in Taekwondo for those over 50

Training in Taekwondo for individuals over 50 can provide numerous physical and psychological benefits, but it also requires certain care and consideration, especially due to the changes that occur in the body and joints with age. One of Taekwondo's major advantages is its versatility; although the sport is known for its fast kicks, it can also be practiced in a gentler manner as one ages. Taekwondo training in older age is beneficial for maintaining physical function, as it preserves and enhances muscle strength, mobility, balance, and physical endurance.

In terms of muscle strength, Taekwondo particularly develops the muscles of the lower limbs, which are activated through kicking and movement. An important benefit for those over 50 is that preserving muscle strength helps reduce age-related muscle loss (sarcopenia). Additionally, Taekwondo training improves mobility, which prevents the stiffening of joints, especially in the hips, knees, and ankles.

The practice of the sport also enhances balance and coordination, as it includes movements that require body control and mobility at various levels. Balance improves especially through kicks, basic technique movements, and changes in direction, which can reduce the risk of falls in older adults.

Although Taekwondo is a martial art, it also includes a significant amount of aerobic exercise. The combination of fast movements, such as kicks and jumps, raises the heart rate and improves cardiovascular and respiratory function. Endurance and aerobic capacity naturally decline with age, but regular Taekwondo practice can help slow this process and improve cardiovascular and respiratory system performance.

While there are clear physical benefits to practicing the sport for functional fitness, it is important to consider the changes in physical characteristics that occur with aging. Taekwondo is a physically demanding sport that involves powerful kicks, jumps, and rapid movements. This can strain the joints, particularly the knees, hips, and ankles. For individuals over 50, it is important to listen to one's body and avoid excessive strain. Overloading muscles or performing rapid movements can cause joint pain or injuries, especially if joint elasticity has decreased or muscle flexibility is reduced.

With aging, the elasticity of joints and muscles decreases. This means that attention should be given to muscle strength and mobility, particularly in the warm-up and recovery phases of training. For those over 50, it may be beneficial to include additional mobility exercises in their program to improve flexibility and prevent muscle and joint stiffness.

Fast movements and coordination required for jumps can be challenging if body mobility and balance are not optimal. Exercises should be adapted to one's level, progressing gradually. In Taekwondo, it is important to focus on correct technique, as incorrect movements can lead to injuries.

With aging, the body doesn't recover as quickly as it once did, so adequate rest and recovery are essential. Training intensity should be adjusted according to age and physical condition. Overtraining can lead to exhaustion, and prolonged fatigue can make one more susceptible to injury.

For those over 50, Taekwondo practice should be carried out with attentiveness to the body's signals. It is important to perform exercises according to one's physical condition and to adapt them as needed. For those who started training at a younger age, it might be challenging to adjust their practice in response to changes in the body, as their perception of training might differ from the capabilities they have in later life. However, it is essential to acknowledge that training should be adjusted according to functional capacity, especially if excessive pain or injury arises.

As we age, more attention should be paid to sufficient warm-up. A well-structured and diverse warm-up prepares the body for exertion and helps prevent injuries. A good warm-up activates the respiratory and circulatory systems, warms up tissues, stimulates the neuromuscular system (brain, movement nerves, proprioception), activates the muscles and stabilizing muscles needed for the workout, and enhances focus and mental readiness.

In training, fast and demanding movements can be challenging, so it is advisable to start with lighter exercises and gradually increase intensity as the body becomes accustomed to the load. Balance and coordination exercises, which improve body control and, consequently, maintain functionality and prevent falls, are particularly beneficial for older adults.

As is generally the case, fast and skill-intensive exercises should be placed at the beginning of the training session when the muscles and nervous system are not yet fatigued. Strength and endurance exercises should be done toward the end of the session. Mobility exercises can be done in the warm-up (preferably dynamic mobility exercises) and at the end (which can be static, but attention should be given to the intensity of the training).

In addition to Taekwondo practice, it is also beneficial to include other poomsae of endurance and strength training, such as gym workouts and aerobic exercises (walking, jogging, etc.), to maintain and improve muscle strength and cardiovascular function.

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