Bachelor's thesis

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Department of Neuromedicine and Movement Science

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The Efficacy of Resistance Training to Reduce Symptoms of Patellar Tendinopathy for Athletes

Bachelor's thesis in Human Movement Science
Supervisor: Astrid Ustad
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Abstract

Background: Patellar tendinopathy (PT) is a common overload injury among athletes competing in activities with high demand for power and speed. This review aims to evaluate the effect of different resistance training interventions to reduce symptoms of patellar tendinopathy in athletes, using The Victorian Institute of Sport Assessment-Patella (VISA-P) questionnaire. **Method**: The literature was retrieved from two different databases (Web of Science and SPORTDiscuss), which resulted in nine relevant studies, focusing on athletes with PT. **Results**: Overall the different resistant training interventions resulted in a significant improvement in the VISA-P score. **Conclusion**: This review found that resistance training is effective in reducing symptoms of patellar tendinopathy in athletes. However, the efficacy of different resistance training interventions remains unclear due to the complex nature of the condition. Despite the findings of this review, it is difficult to conclude with one specific treatment for PT, as further research is needed to determine the efficacy of the interventions during the season.

Abstrakt

Bakgrunn: Patellar tendinopati (PT) er en vanlig overbelastningsskade blant utøvere som konkurrerer i idrett der det kreves mye kraft og hurtighet. Denne analysen evaluerte effekten av ulike intervensjoner av styrketrening, for å redusere symptomer på PT hos idrettsutøvere, ved å bruke Victorian Institute of Sport Assessment-Patella (VISA-P) spørreskjema. **Metode**: Det ble foretatt et litteratursøk i to forskjellige databaser (Web of science og SPORTDiscuss), som resulterte i ni relevante studier som omhandlet atleter med PT. **Resultat**: De forskjellige styrketrening intervensjonene viste en signifikant forbedring i VISA-P skalaen. **Konklusjon**: Dette studiet fant at styrketrening er effektivt for å redusere symptomer på patellar tendinopati hos idrettsutøvere. Effektiviteten av de ulike intervensjonene er fortsatt uvisst, på grunn av kompleksiteten til skaden. Til tross for funnene i dette studiet, er det vanskelig å konkludere med en spesifikk intervensjon, videre forskning trengs for å fastslå effektiviteten av intervensjonene i løpet av sesong.

1. Introduction

Tendinopathy is one of the leading sources of dysfunction among the general population, especially athletes (1). Patellar tendinopathy (PT), also known as "jumper's knee", is characterized by pain in the knee, localized where the patellar tendon attaches to the patellar bone (2–4). Several factors may influence the development of PT, such as weight, body mass index (BMI), biomechanics, flexibility, and strength (5). The prevalence of PT is highest in activities with a high demand of power and speed, such as soccer, volleyball, and athletics (6). Furthermore, the reported prevalence of PT in explosive sports, among elite athletes is as high as 14%, and among recreational athletes 9% (3). In addition, it has been reported that the prevalence of PT among male volleyball players can be as high as 45% (3,6). This is due to repetitive loads on the tendon caused by jumping, landing, and physically demanding work (4). PT can limit participation in activities/sports, decrease function, and can have a high impact on quality of life (7,8). Cook et al. (9) investigated the clinical course of PT on athletes and found that within six months, more than 25% of their participants were not able to return to sports activities. Furthermore, a prospective follow-up study found that more than 50 % of athletes suffering from PT were forced to retire from active sports due to pain (10).

There are multiple ways to manage PT symptoms, involving treatments like; anti-inflammatory medications, bracing, kinesio-taping, cryotherapy, shockwave therapy, platelet-rich plasma injections, surgery, and resistance training (11). Resistance training can be defined as using resistance to build physical strength, it also makes bones harder and may reduce the risk of injury (1). Due to the demanding nature of physical activity and its substantial impact on the joints and muscles, it becomes crucial for athletes to develop sufficient body strength to ensure optimal body function (1). Other important factors to manage PT are resting and avoiding activities that can trigger pain (1). Surgical treatment remains as the last resort in case of an overuse injury that has been unresponsive to conservative treatment (12,13). Consequently, various treatments used to address PT issues can frequently result in a reduction or, in more severe cases, complete discontinuation of sport participation, with limited evidence supporting their efficacy (2,9,13).

Resistance training includes various forms of exercises aimed at enhancing muscle strength, these encompass isotonic, isometric, and plyometric training methods. Heavy slow resistance training (HSR) is a classic example of an isotonic intervention, which involves performing a squat slowly and controlled with a heavy load. The movement is divided into two phases:

eccentric (lowering phase) and concentric (lifting phase) (14,15). Isotonic exercises involve muscle contractions that result in a change in muscle length, while isometric exercises involve contractions where the muscle length remains constant (14). Plyometric exercises, on the other hand, focus on explosive movements involving rapid stretching and contracting of muscles to enhance muscle power, speed, and agility. They start with low intensity and gradually progress to match the athlete's demands of the sport they are playing (13). Progressive tendon-loading exercises (PTLE) is a training protocol, focusing on building energy storage and utilization in the tendon before progressing to sport-specific exercises. The training protocol involves; isometric, isotonic, energy storage, and sport-specific exercises aimed to facilitate a gradual return to sports activities (16). Studies often distinguish between isotonic exercises, which serve as a common denominator for various dynamic training techniques like eccentric, concentric, and HSR, and isometric exercises, which focus on static resistance training (2,3,5,7,12,17–20).

There are many ways to measure results, such as function tests, imaging, and questionnaires. VISA-P is short for The Victorian Institute of Sport Assessment-Patella (21) and is a valid questionnaire used to assess symptoms, function, and the ability of individuals to engage in sports activities during the rehabilitation of PT (21). The widely recognized questionnaire includes eight questions and measures pain and function on a scale ranging from 0-100, where a score of 100 indicates maximum function and no pain (21). Researchers have used different statistical measures, combinations, and reporting methods to present VISA-P scores in studies (2,3,5,7,12,17–20). These include measures such as the mean with a 95% confidence interval (CI), the median, interquartile range (IQR), and range. Regarding the choice of presentation, the format depends on the specific research and its aim.

PT is a common and debilitating condition affecting athletes all over the world. Repetitive loads from various activities can cause PT, resulting in reduced activity and impaired function. Rehabilitating from this overuse injury can be a complex and demanding process, requiring careful handling, guidance, and patience to ensure a successful recovery. For an athlete it can be daunting trying to navigate through various types of resistance training approaches, making it difficult to treat effectively. Given these complexities, the purpose of this review was to evaluate the effect of different types of resistance training interventions for reducing symptoms of patellar tendinopathy in athletes, measured with VISA-P.

2. Method

The literature search was retrieved from two databases, Web of Science and SPORTDiscuss. Using the keywords “rehabilitation”, “recovery”, “treatment”, “intervention”, “exercise”, “physical activity",” training”, "jumper's knee", "patellar tendinopathy", "patellar tendonitis", and "jumper's knee" provided a result of 215 papers on SPORTDiscuss and 420 papers on Web of Science. All studies that were included had to be published in English, conducted on humans, and the keywords had to be present in the abstract, title, or keywords. The papers also had to have a full text available and focus on exercise treatment and the injury of patellar tendinopathy. Which resulted in 25 different original papers of interest. Furthermore, inclusion criteria were 1) outcome measurement VISA-P (The Victorian Institute of Sport Assessment-Patella), 2) >20 participants, 3) clinically proven PT, and 4) athletes. In total, the search resulted in nine relevant studies that were included in this review.

3. Results

Table 1 gives an overview of nine articles that examined resistance training as an intervention for athletes with PT and measured VISA-P as one of their outcomes.

***Table 1**: Overview of the results of the nine original studies*

Author	Age Mean± SD	n (M/F)	Intervention groups	VISA-P* baseline to follow up	Conclusion
van Ark et al. 2015 (2)	G1: 22.9 ± 4.9 G2: 23.1 ± 4.7	29 (M27/F2)	G1: isometric G2: isotonic	Median (IQR) G1: 66.5 (59.5-75.8) to 75 (72.5-87) G2: 69.5 (55-75.8) to 79 (67-86)	Both groups improved significantly and no significant between-group difference
Agergaard et al. 2021 (3)	G1: 28.8 ± 5.1 G2: 32.3 ± 4.9	44 (M44/F0)	G1: Isotonic (HSR) G2: Isotonic (MSR)	Mean (95% CI) G1: 58.8 (49.8-67.8) to 70.5 (61.3-79.7) to 79.7 (70-89.4) G2: 59.9 (54.8-65) to 72.5 (66.5-78.5) to 82.5 (77.4-87.8).	Both groups improved significantly and no significant between-group difference
Breda et al. 2021 (5)	24 ± 4	76 (M58/Fx)	G1:Progressive tendon-loading exercises (PTLE) G2 Isotonic (Eccentric)	Mean (95% CI) G1: 56 (52-61) to 84 (79-89) G2: 57 (53-62) to 75 (69-82)	Both groups improved significantly. A significant between-group difference in favor of the PTLE group.
Ruffino et al. 2021 (7)	G1: 27.5 ± 5.4 G2: 31.7 ± 8.7	42 (M41/F1)	G1: Isotonic (Inertial flywheel) G2: Isotonic (HSR)	Mean (points) G1: 52 to 74.2 (+22.2) G2: 52 to 74.8 (+22.8)	Both groups improved significantly and no significant between-group difference
Fhrom et al. 2007 (12)	G1: 26 ± 8 G2: 28 ± 8	20 (M16/F4)	G1: Isotonic (eccentric) G2: Isotonic (eccentric)	Median (95%CI) G1: 49 (38-61) to 86 (71-92) G2: 36 (23-61) to 75 (46-83)	Both groups improved significantly and no significant between-group difference
Rio et al. 2019 (18)	+18^ ± x	25 (M19/F6)	Isometric	Mean change (SD) 12.2 (8.9)	Improved significantly
Jonson and Alfredson 2005 (20)	G1: 25.7 ± 9.9 G2: 24.1 ± 6.4	15 (M13/F2)	G1: Isotonic (eccentric) G2: Isotonic (concentric)	Mean (SD) G1: 41.1 (17.9) to 83.3 (23.4) G2: 40.7 (±16.3) to 37 (±4.6)	G1 Improved significantly G2:No significant difference
van Ark et al. 2018 (17)	22.7 ± 4.7	29 (M16/F2)	G1: Isometric G2: Isotonic	Median (IQR) 68 (57-76) to 82 (73-88)	Both groups improved significantly and no significant between-group difference
Rio et al. 2017 (19)	22.5 ± 4.7	20 (M18/F2)	G1: Isotonic G2: Isometric	Median (range) G1: 69.5 (45-83) to 80 (64-94) G2: 72.5 (13-88) to 84 (41-100)	Both groups improved significantly and no significant between-group difference

VISA-P=Victorian Institute of Sport Assessment; n= Number of subjects; *= The VISA-P results are presented as median or mean, pending on what the study presented the result as; ^= All participants were over 18 years old; x= missing data; M= Male; F= Female; IQR= Inter Quartile Range; CI= Confidence interval; SD= Standard Deviation

The study done by van Ark et al. (2) examined if isometric and isotonic exercises relieved pain in competing athletes with PT. Twenty-nine (M27/F2) jumping athletes playing at least three times per week, were randomized into two groups. The intervention included four exercise sessions per week. The VISA-P scores improved significantly for both groups, over the four-week intervention. The isometric VISA-P score increased from a median of 66.5 (IQR 59.5-75.8) to 75 (IQR 72.5-87) points (p=0.028) and the isotonic score increased from a median of 69.5 (IQR 55-75.8) to 79 (IQR 67-86) points (p=0.003). The median change was nine points (IQR 3-25) and there was no significant difference in VISA-P score change between the groups (p=0.965).

Agergaard et al. (3) investigated if the load magnitude influenced the effect of a 12-week loading intervention for PT in the short term (12 weeks) and long term (52 weeks). Forty-four male athletes were randomized into a moderate slow resistance group (MSR) (55 % of one repetition maximum (RM)) and a heavy slow resistance group (HSR) (90 % of 1RM). The intervention for both groups had three weekly sessions, with two exercises (one bilateral leg press and one unilateral knee extension). The VISA-P score in both groups increased significantly from baseline to short-term and long-term follow-up ($p<0.0001$). The HSR group mean scores went from baseline 58.8 (95% CI 49.8-67.8) to follow-up 70.5 (95% CI 61.3-79.7) in week 12 and to 79.7 (95% CI 70-89.4) in week 52. The MRS group had a mean baseline score of 59.9 (95% CI 54.8-65) to 72.5 (95% CI 66.5-78.5) in week 12 and in week 52 it was 82.5 (95% CI 77.4-87.8).

The study by Breda et al. (5) compared the effectiveness of progressive tendon-loading exercises (PTLE) with eccentric exercise therapy in patients with PT. Seventy-six athletes (M58/Fx) were randomized into two groups. The PTLE intervention comprises four stages, involving specific exercises and progression. In the first stage, isometric exercises are performed daily, consisting of five repetitions of 45 seconds of single leg extension and single leg press. The second stage involves isotonic exercises, performed every other day, including single leg extension and single leg press of four sets with 15 repetitions, gradually reducing the number of reps while increasing the load. Thirdly, plyometric loading and running exercises on every third day, starting with three sets of 10 repetitions using both legs and gradually progressing to six sets using one leg. The last stage focuses on the sport-specific exercises tailored to the individual chosen sport. The eccentric exercise therapy control group performed pain-provoking single-leg squats on a decline board, twice a day for

a duration of 12 weeks, followed by sport-specific exercises. The estimated mean VISA-P score improved significantly from 56 (95% CI 52-61) at baseline to 84 (95% CI 79-89); $p<0.001$ at the 24-week follow-up in the PTLE group. There were also significant improvements in the eccentric exercise therapy group from 57 (95% CI 53-62) to 75 (95% CI 69-82); $p<0.001$. In favor of the PTLE group, there was a significantly adjusted mean between-group difference at week 24, with nine points (95% CI 1-16) ($p=0.023$).

Ruffino et al. (7) investigated the efficacy of inertial flywheel (a machine that holds constant speed) and HSR. Forty-two (M41/F1) participants in a 12-week intervention were randomized into two groups. Both groups consisted of three supervised exercise sessions per week for 12 weeks. Both groups had a significant improvement in VISA-P scores ($p<0.05$), there was no statistically significant between-group difference ($p=0.506$). The VISA-P scores in both groups were between 22.2 and 22.8 points.

Fhrom et al. (12) compared the efficacy and safety of two eccentric rehabilitation protocols. Twenty athletes (M16/F4) with PT went through a 12-week intervention and were randomized into two groups. One group used unilateral eccentric body load training with a decline board twice a week, and the other group used the Bromsman device (a specialized training equipment designed to provide bilateral eccentric overload during resistance training) twice a week, supplemented with daily home exercises. Both groups improved significantly in the 12-week rehabilitation period ($p<0.001$), and there were no significant differences between the two groups. VISA-P scores increased from a median of 49 (95% CI 38-61) to 86 (95% CI 71-92) in the first group. For the second group, the median score increased from 36 (95% CI 23-61) to 75 (95% CI 46-83) points.

The study by Rio et al. (18) looked into the effectiveness of an isometric squat exercise using a portable belt, on patellar tendon pain and function, in athletes during their competitive season. Twenty-five athletes (M19/F6) did a five times 30-second isometric quadriceps squat exercise using a rigid belt, daily. The VISA-P scores improved significantly at the end of the intervention of four weeks with a mean change of 12.2 $\pm$8.9 points ($p<0.001$). This study had two dropouts, both females reported knee pain or swelling.

Jonson and Alfredson (20) compared painful eccentric with painful concentric quadriceps training on a decline board. Fifteen athletes (M13/F2) were randomized into two groups. The intervention was 15 exercises, repeated three times, twice a day, every day. In the first six

weeks, the athletes cut all sporting activity. Their mean VISA-P scores after 12 weeks were significantly higher (83 vs. 37, $p<0.001$) in the eccentric group compared to the concentric group. The baseline mean VISA-P score for the eccentric group was 41.1 ± 17.9 and increased significantly to 83.3 ± 23.4 at the 12-week follow-up ($p<0.005$). The baseline VISA-P score in the concentric group was 40.7 ± 16.3 and showed no significant difference at the 12-week follow-up, 37 ± 4.6 ($p<0.34$). None of the athletes in the concentric group were satisfied with the treatment and had to quit sporting activities.

Another study done by van Ark et al. (17) investigated the effects of a four-week in-season exercise program of isometric and isotonic exercises on tendon structure and dimensions as quantified by ultrasound tissue characterization. Twenty-nine (M16/F2) volleyball and basketball players with PT were randomized into an isometric group and an isotonic group. The intervention programs were designed to decrease PT pain and were performed four times per week. The isometric group performed five sets of 45 seconds of single-leg isometric holds. The isotonic group executed four sets with eight repetitions and single-leg isotonic contractions. The VISA-P showed a significant improvement after four weeks in both groups, with no difference in clinical outcomes between the groups. The score went from a median of 68 (IQR 57-76) at baseline to 82 (IQR 73-88) ($p=0.002$).

Rio et al. (19) also compared the immediate analgesic effects of two resistance programs in season. Twenty (M18/F2) jumping athletes were randomized into two different quadriceps resistance protocols. Group one did isometric leg extension holds at 60 degrees knee flexion (80 % of their maximal voluntary isometric contraction) five times 45 sec holds. Group two did isotonic leg extension (80 % of their 8RM) four times eight repetitions. The groups did these exercises four times per week for four weeks. The baseline median VISA-P score in the isotonic group was 69.5 with a range of 45-83. The isometric group scored 72.5 with a range of 13-88. At the end of the intervention, the median VISA-P score for the isotonic group was 80 with a range of 64-94 and the isometric group had 84 with a range of 41-100. Both groups improved significantly, with no significant difference between groups ($p=0.99$).

4. Discussion

Nine studies were included in this review to evaluate the effect of different types of resistance training for reducing symptoms of PT in athletes, measured with the VISA-P questionnaire. The main finding of all the studies demonstrated that resistance training improved symptoms of PT significantly (2,3,5,7,12,17–20). The included resistance training interventions consisted of HSR, MSR, eccentric, concentric, inertial flywheel, isometric, and PTLE. When developing resistance interventions for athletes with PT it is important to consider individual factors such as injury severity and duration, as well as load magnitude and frequency.

4.1 Sample selection and characteristics

There is a large gender gap shown in studies about the treatment of PT, supporting previous research that PT is primarily a condition of male athletes and is particularly more common in those with greater jumping ability (18). Even though, recent studies have revealed that many women active in sports are affected (22). This review examined a total of 297 participants, with only 19 of them being women (2,3,5,7,12,17–20). The dominant portion of males shows that women represent a minority of the patients included in studies of PT (22). This finding is noteworthy, considering that women are at greater risk of substation tendon injuries during physical activity, due to several factors including hormone fluctuation, which leads to lower tendon stiffness and worse adaptation to mechanical loading than men (22).

4.2 Mechanisms of action

The treatment that seems to be preferred for tendinopathy is loading interventions, where the optimal number of sets, repetitions, loads, and frequencies, are still debated (3). The mechanisms underlying the efficacy are still unclear but previous research suggests that it improves symptoms of PT, by improving tendon structure and composition (16). In addition, resistance training has been shown to improve neuromuscular adaptation which helps reduce PT symptoms, by increasing muscular strength and improving motor control (16).

This review found that eccentric resistance training resulted in a good option for soothing pain and improving function (5,12,20). The eccentric movement lengthens the tendon and muscles under load and stimulates the tendon's ability to become resilient by improving the ability to adapt (12). These findings correspond to earlier studies that investigated resistant training as a long-term treatment for PT (11). Isolated concentric resistance training, on the

other hand, may not be considered as effective in reducing symptoms of PT, due to the overload of pressure on the tendon (20). However, isometric exercises improve symptoms of PT short term, thus isometric holds can have an acute effect on pain relief (2,5,17–19). This pain relief may lead to higher participation in training and higher activity intensity, while also reducing the time athletes spend in pain. Isometric exercise has been proven to immediately reduce patellar tendon pain and at the same time immediate muscle performance improvements due to quadriceps maximal voluntary contraction improvements (18).

Although the results showed improvements for the interventions it is important to include the possible negative effect of this type of resistance training, especially for athletes with PT. Visnes et al. (23) found no significant improvement in PT with eccentric training among volleyball players in-season. This indicates that eccentric exercise may show little to no effect, or even pain for athletes during the season (23,24). This could be linked to insufficient recovery time between training and competition, due to the high demands of their sport (19). Rest is an essential component of recovery from PT, hence the result of the interventions possibly has been influenced by time spent resting, decreased or cut in other sporting activities during rehabilitation time. Isometric exercises, on the other hand, may have an advantage over the other resistance training modalities, when considering the safety of athletes (25). Cook and Purdam (25), noted that isometric exercises did not cause excessive tendon loading or tissue damage. This can specifically be relevant for athletes who are recovering from PT and need to gradually increase their training load without aggravating the injury. Despite the findings of this review suggesting that isometric exercises can assist athletes in managing pain during an active season, it is essential to acknowledge the need for further research to ascertain its efficacy.

Previous research has stated that eccentric resistance training is the superior method for managing PT (13,14). However, it could become provocative when combined with the high loads that are already present in a competitive season (18). Consequently, it is essential to consider the appropriate time of rest and load magnitude to avoid overloading the affected tendons (19). Agergaard et al. (3) found that isolated eccentric exercises should not be the sole focus of tendon-loading interventions. Consequently, recent studies have explored alternative load and strength interventions such as, including more isometric exercises, HSR, and PTLE (3,5,7,18).

The findings of this review align with the research conducted by Kongsgaard (15), who implemented a HSR protocol for PT treatment. Thus, the results indicate that isotonic resistance training, particularly with the use of HSR, has demonstrated positive effects on pain reduction and functional improvement (3,7). Agergaard et al. (3) discovered that HSR gives a better long-term response compared to eccentric load. This intervention involves performing a movement slow and controlled, using a heavy load, and aims to improve the load-bearing capacity and resilience of the patellar tendon (3,7,15). As HSR is a known treatment for PT, Agergaard et al. (3) interestingly found that a moderate load showed equal improvement as a heavy load. Regarding clinical outcomes, both interventions (MSR and HSR) improved function and structure. Ruffino et al. (7) compared two isotonic interventions to treat PT among athletes, HSR and inertial flywheel. This resulted in equal satisfaction regarding pain and function, thus inertial flywheel is also considered to be an alternative to treat PT.

Previous studies support the findings of this review, that among the different interventions, there are short-term and long-term effects on the pain level during activities in PT (19). Breda et al. (5) investigated the effectiveness of PTLE compared to eccentric exercise therapy, which discovered that PTLE improved symptoms significantly in athletes with PT in season. One essential factor of PTLE intervention is that it includes both isometric and isotonic exercises. PTLE was less painful to perform, in contrast to eccentric exercises that are usually pain-provoking (5). This is because isometric exercises are introduced in the early stage to decrease pain immediately, followed by isotonic exercises used to help muscle strengthening, which aids to reduce pain sensitivity (16). In particular, for athletes, the explosive exercises prior to sport-specific exercises in PTLE distinguished this intervention from other resistance training interventions. This may be due to the body's ability to adapt and withstand (absorb and transfer) the forces during physical activity (16).

4.3 Feasibility and practicality

Being an athlete is time-consuming, whether they play at a moderate level or elite level. Several factors regarding time need to be considered, such as sport-specific time, strength training, and time spent with friends and family to maintain a high quality of life. Regarding findings of this review, training interventions varied in time commitment, eccentric interventions typically involved a longer duration of training sessions (approximately 50-70 min.) (5,12,20), while HSR training and isometric interventions generally required shorter

sessions (approximately 30-50 min.) (2,3,7,16,18,19). The PTLE intervention requires a higher overall time commitment, hence the four-stage program. However, PTLE was found to be feasible and beneficial in the long term (5). Considering the load magnitude for athletes, this factor varies depending on the type of sport and individual biomechanics. The different resistance training interventions have distinct loads and weights on the athlete. For instance, HSR interventions use heavy weights, resulting in a greater load on the patellar tendon (15). Isometric interventions, on the other hand, may provide a less intense loading stimulus (19). In the matter of PTLE intervention, it gives a balanced approach by combining both intense and low loads to the tendon throughout its four stages, taking into consideration the specific needs and requirements of the athlete's rehabilitation journey (16).

When it comes to resistance training the choice and requirement for equipment can vary, depending on the specific type of exercise. Accordingly, it might make some interventions more feasible and practical as treatment methods for PT. Inertial flywheel and HSR are exercises requiring either access to heavy weights, a rack, or a specific machine (3,7,15). In contrast, isometric, eccentric, and PTLE do not demand the same equipment, therefore it could be considered a more expedient treatment option (2,5,12,17–20). Nonetheless, if the athletes have easy access to the necessary equipment, which is often available at sports facilities, both inertial flywheel and HSR rehabilitation interventions become practical choices for addressing PT. Additionally, isometric exercises can potentially have an advantage compared to the other interventions considering their portability. Thus athletes usually have several training sessions per week and games on the weekend, and often they have to travel to play. Isometric exercises can be done without- or with minimal portable equipment, and minimal space, which makes it convenient for athletes that travel frequently (18).

Considering athletes in season, several of the treatment interventions instructed cutting sporting activities at the beginning of the intervention (5,12,20). This can be challenging for athletes, as they need to stay active in their specific sport during rehabilitation to maintain progress and avoid setbacks in their athletic abilities. Isometric, on the contrary, allows controlled loading of the tendon without the additional strain of isotonic contractions (16). Due to an athlete's total training load per week, it is crucial to consider the tendon load, therefore isometric should be considered a valuable alternative for treatment of PT for athletes during the active season (2,18,19). However, rest is still an essential factor, thus the body needs to recover. Therefore further research is needed to determine training frequency and load

magnitude (19). Unfortunately, many athletes continue to play despite experiencing pain and reduced function from PT, which often leads to the end of their careers. This is especially due to the complex nature of treating PT effectively (18).

4.4 Methodical assessments - limitations and strengths

A strength in this review is the utilization of the VISA-P questionnaire as a primary outcome measure in all nine included articles (3,5,7,12,17,18,20). The consistent use of the VISA-P across multiple studies ensures a standardized and objective assessment of symptoms, function, and the ability to engage in sports activities. This uniformity in outcome measurement strengthens the validity of the findings in this review. Furthermore, the fact that only two studies employed the VISA-P as a secondary outcome underscores its prominence as a reliable tool for evaluating PT (2,19).

An additional advantage of this review is the inclusion of participants, encompassing athletes, and young adults, diagnosed with PT. This provided a specific and relevant population for the interventions under investigation. The consistent application of inclusion criteria across the nine studies establishes a foundation for generalizing the findings to similar populations. However, it is important to acknowledge the limitation of a gender imbalance, with a relatively small number of female subjects (19/297 subjects reported as female). This limitation may restrict the generalizability of the results, particularly regarding the effectiveness of the interventions in both male and female athletes.

The main limitation of this thesis was that the studies used different units of measure in the VISA-P score results. Five studies reported the mean VISA-P scores to evaluate pain and function (3,5,7,18,20), and the remaining four studies used the median as a measure, due to substantial differences in VISA-P scores within the intervention groups (2,12,17,19). Additionally, the included studies utilized various statistical parameters such as 95 % confidence interval, interquartile range (IQR), standard error of the mean (SEM), and range, which further contributed to measurement variability. This lack of consistency in measurement methods poses a difficulty in reaching accurate conclusions based on the aggregated data.

Another limitation could be the distinction between intervention and follow-up period. Four of the studies had an intervention period of only four weeks and a follow-up at the end

(2,17–19). While the intervention of the remaining five studies lasted for 12 weeks, with follow-up in week 12 (7,12,20), week 24 (5), and week 52 (3). Therefore, reducing pain and gaining function for athletes with PT can potentially benefit from being divided into short-term and long-term treatments.

5. Conclusion

The findings of this review show that resistance training is an effective intervention for reducing symptoms of patellar tendinopathy in athletes. In light of the findings, the efficiency of different types of resistance training remains unclear, due to the complex nature of the condition. The field of sports medicine is constantly evolving and there is no golden standard in the treatment of PT, studies also use a variety of interventions, types of athletes, and measurement methods. It is therefore challenging to provide one specific resistance training method for the treatment of PT among athletes in general. Athletes can benefit from the most common treatment method of PT, which involves isotonic interventions. However, it is worth considering newer findings, like isometric squat holds, and implementing them during the season to efficiently manage symptoms of PT. Based on the findings, PTLE has been recommended for athletes, as a potential intervention for managing and treating PT. However, it is important to carefully consider the timing and intensity of training, due to differences in injury progression. Further research is needed to optimize the interventions used in clinical practice, additionally, look into the dose and intensity of the exercise interventions along with the athlete's specific phase in their season. Finally, it is important that future studies should consider including larger sample sizes, specifically women, and more consistent measurement methods to improve the overall quality of evidence in this field. It might also be interesting to include reported recurrence and long-term results of the return to preinjury level sport and activity.

6. Reference

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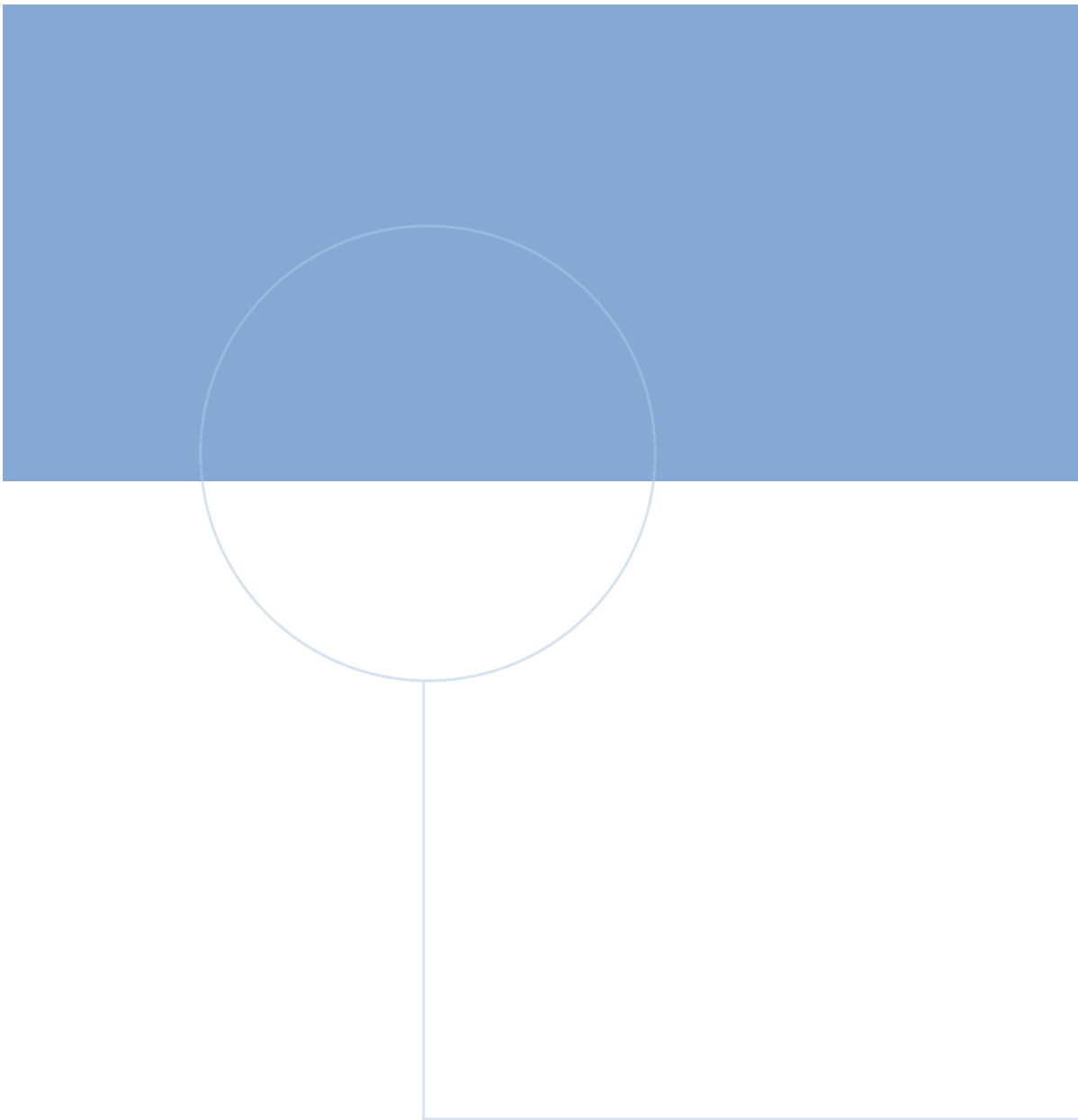

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