Effect of Eccentric Exercises at the Knee with Hip Muscle Strengthening to Treat Patellar Tendinopathy in Active Duty Military Personnel: A Randomized Pilot

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ABSTRACT

Background and Purpose: Tendinopathy is an over-use condition that results in painfully reduced exercise tolerance, mechanical loading capacity, and function negatively impacting soldiers and mission readiness. Investigation of conservative treatment options is critical to facilitate mission readiness. The purpose was to evaluate and compare clinical outcomes (pain and function) following eccentric training (decline squats) with and without the addition of proximal hip strengthening exercises. **Methods:** Forty-one activity duty soldiers (mean age 29.3 years, range 19-38) with patella tendinopathy were randomized to a standard of care (SOC) group (n=17) or treatment group (n=14). **Intervention:** The SOC group performed unilateral 25° eccentric squats (3 sets of 15 repetitions, 2 times per day) for 12 weeks. The treatment group performed the same exercises plus concentric hip strengthening (3 sets of 10 repetitions, 3 times per week) for 12 weeks. **Findings:** We found no significant differences between groups for any of the outcome measures. We observed significant within group differences for all outcome measures. The LEFS SOC increased from 57.7 to 66.8 (p=0.008) and the treatment LEFS increased from 54.8 to 64.8 (p=0.007) at 24 weeks. The VISA-P SOC increased from 51.7 to 70.4 (p=0.001) and the treatment group increased from 51.8 to 72 (p=0.002) at 24 weeks. Both groups reached minimal clinical important difference (MCID) for LEFS and VISA-P at 24 weeks. **Clinical Relevance:** Soldiers may want to consider the addition of hip strengthening as a feasible intervention for the treatment of patellar tendinopathy. **Conclusion:** Favorable effects were demonstrated with patellar tendinopathy using either a combined treatment of eccentric squat and hip muscle strengthening or SOC eccentric squat only group over a 24 week follow-up. The results suggest either treatment strategy is likely to result in improvements when treating an active duty military population.

Key Words: eccentric decline squat, hip strengthening, patellar tendinopathy

Tendinopathy is an over-use condition that results in painfully reduced exercise tolerance, mechanical loading capacity, and function.[1] Clinical management of tendinopathy can be challenging because current treatments fail to return athletes to competitive sport.[2] Such mediocre results can lead to submaximal performance and forced retirement.[3] Patellar tendinopathy is of particular interest to the military, as persistent symptoms with running and jumping can negatively impact soldiers and overall mission readiness. Investigation of conservative treatment options in this population is critical to foster cost-effective mission readiness.

Accurate prevalence data for patellar tendinopathy within the active duty military population is unknown. However, 15.1% of musculoskeletal complaints in a Marine basic training group were classified as patellar tendinitis.[4] Of all exercise and sport-related injuries, 11.8% were classified as tendinitis/bursitis.[5] Tendinitis implies an active inflammatory process; whereas, tendinopathy signifies a generalized pathology in the tendon that includes tendinitis and tendinosis. Determination of the prevalence of either condition appears elusive. Additionally, 41% of all injuries requiring restricted duty were due to anterior knee pain.[6] Anterior knee pain is an all-encompassing term used to describe symptoms around the front of the knee, which due to its general symptomology may include patellar tendinopathy.[7,8] Overuse injuries such as patellar tendinopathy result in a median time of limited or reduced activity of greater than or equal to 15 days[5] to 6 months[6] in non-basic training soldiers. The indirect cost of lost or reduced capabilities and additional manpower required to perform the mission of an injured solider cannot be calculated, but given the median time of up to 6 months of reduced physical capabilities, the burden is considered substantial.

Identifying pain generators in patellar tendinopathy is arduous, with little-to-no evidence of inflammatory cells in the tendon.[9,10] Pain has been postulated to arise from neovascularization,[11-13] chemical irritants such as prostaglandins or neurotransmitters,[14,15] central/peripheral sensitization,[16,17] and mechanical loading.[1,18] Thus, prescribing the correct treatment is daunting. Larsson et al[19] reviewed treatments for patellar tendinopathy which included exercises, injections (corticosteroid and sclerotic agents), extracorporeal shock wave therapy, and surgery and concluded that "physical training, particularly eccentric exercises"[19(p1632)] should be the first line of treatment.

Eccentric exercises effectively reduced pain and improved function in the patellar tendon[12,19–25] for only 50% to 70% patients studied.[2] Perhaps treatment did not include hip muscle strengthening which can also influence knee kinematics. Individuals with patella tendinopathy demonstrated diminished (27%) hip extensor strength[26] and reduced peak knee and hip flexion with jumping[27] causing a sharply increased quadriceps demand[28] leading to mechanically-induced tissue failure. When hip extensor strengthening was combined with jump landing modification during an 8-week intervention, a volleyball player with a 9-month history of patellar tendinopathy experienced a substantial decrease in pain.[29] Frontal plane movements of the femur can alter the line of pull of the quadriceps. Increased hip adduction during walking and running gait[30] produces a valgus-directed force at the knee. Hip abductor weakness is associated with increased valgus force produced at the knee during jumping[31] and step-downs.[32] With altered knee joint kinematics reported in the sagittal and frontal planes during walking, running, jumping, and step-downs, it is plausible that adding hip muscle strengthening to treat patellar tendinopathy may enhance existing treatment outcomes.

The purpose of this pilot study was to evaluate active duty personnel with patellar tendinopathy and compare clinical outcomes (ie, pain rating and function) following eccentric knee extensor training with or without proximal hip strengthening. We expected participants in the treatment (hip strengthening) group would significantly show improved outcome measures over the standard-of-care (SOC) group that only performed eccentric knee extensor training.

METHODS

Study Design

This pilot study assessed and compared outcomes of unilateral, eccentric 25° decline squats combined with hip muscle strengthening for the treatment of patellar tendinopathy on participants' functional status and pain rating, using the lower extremity functional scale (LEFS), Victorian Institute of Sport Assessment – Patella (VISA-P), Visual Analog Scale (VAS) for pain and jump distance with single-leg and triple-hop tests. This study was approved by the Brooke Army Medical Center Institutional Review Board, San Antonio, Texas.

Setting and Participants

Participants were recruited from primary care, physical therapy, and orthopedic clinics at Ft. Sill, Oklahoma. Inclusion criteria were: age older than 18 years; reported > 3 months' history of anterior knee pain with jumping, squatting, running and/or steps/stairs; palpable pain over the patella tendon; VISA-P score < 75; and in active duty service with at least 6 months' time remaining at current duty station. Exclusion criteria were: VISA-P score > 75; reported pain with prolonged sitting or retropatellar pain; history of knee surgery; reported or radiographic evidence of knee osteoarthritis; rheumatic disease; neuromuscular or cardiovascular disease; diabetes; and pregnancy.

Procedures and Interventions

Participants with anterior knee pain were screened for inclusion and exclusion criteria. After obtaining informed consent, descriptive data were collected on all participants as well as hours participating in fitness activities (organized or unorganized). Participants completed the LEFS and VISA-P questionnaires and VAS for pain with activity. Participants performed the single leg hop and triple hop distance testing described by Noyes et al.[33] Three hops were completed on the symptomatic lower extremity and non-symptomatic lower extremity, with the longest distance recorded as the actual distance hopped. For participants with bilateral symptoms, the right lower extremity was recorded as the symptomatic side for consistency. Participants were randomized using sealed opaque envelopes to either a SOC or a treatment group (Figure 1). If a participant had bilateral patellar tendinopathy, both tendons were treated; however, each tendon was treated with the same intervention. The SOC group performed unilateral eccentric decline squat.[20,23] The treatment group received identical care plus concentric hip muscle strengthening exercises similar to the protocol described by Fukuda et al.[34] Both groups received written instructions on how to construct a 25° decline squat board. Exercise progression was based on the pain monitoring system[35] whereby pain up to 5/10 on numeric pain rating (NPR) was considered acceptable to minimize risk of tissue overload while facilitating a treatment effect.

All treatments were conducted by the same physical therapist. During the course of treatment, participants were allowed to continue with their typical fitness routine using the pain monitoring model[35] described where pain should not exceed 5/10 with any activity. Participants were instructed in the use of an exercise log to measure adherence. Participants were seen weekly during the first month to ensure correct exercise technique and progression. After the first month, treatment frequency was based on participant progression and understanding of instructions. The LEFS, VISA-P, VAS for pain with

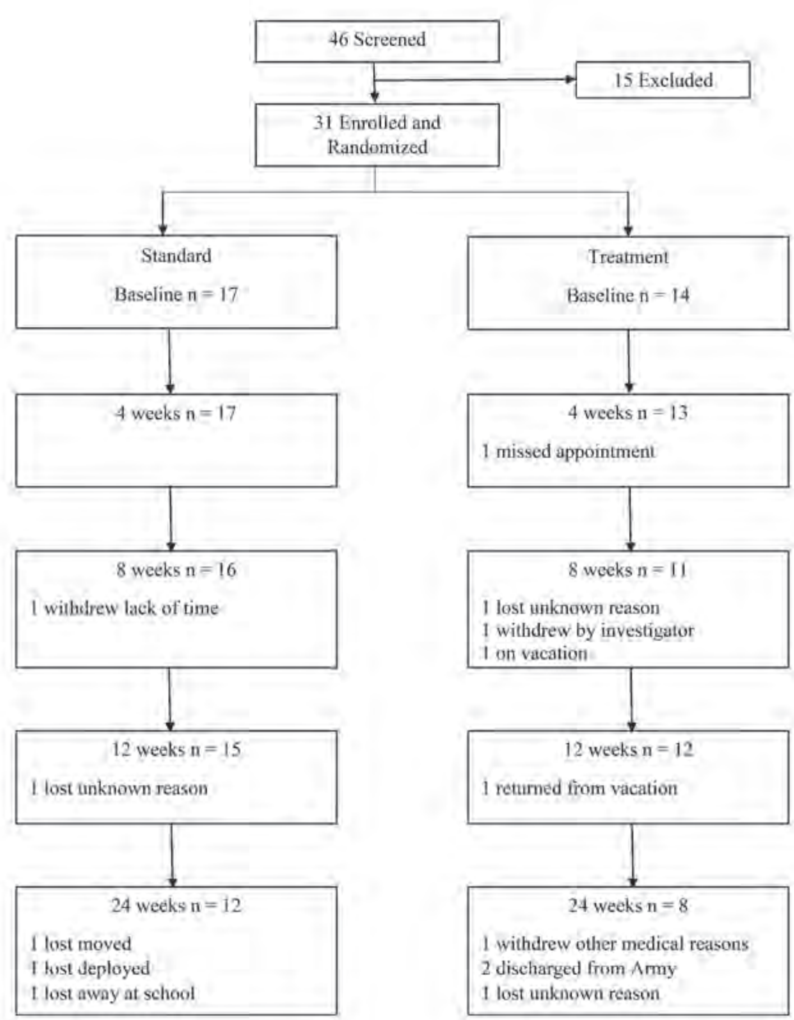

Figure 1. Study flow diagram.

activity, and hop testing were administered by the same therapist performing treatment. All outcome measures were conducted at baseline, 4, 8, 12, and 24 weeks. Participants were instructed to continue with their exercise program between 12 and 24 weeks, but were not seen in physical therapy. They were not prohibited from seeking additional or alternative care.

Outcome Measures

The LEFS is used to evaluate lower extremity musculoskeletal conditions (score 0-80, higher score indicative of high function).[36] The VISA-P is a patella tendinopathy-specific questionnaire, used to evaluate an athlete's symptom severity and function (0-100, higher scores indicate less symptoms/higher function).[37] The VAS for pain with activity is a 10 centimeter line with two anchors. The left anchor is marked as no pain and the right anchor is marked worst pain possible.[38] All are considered reliable and valid outcome measures.

Data and Statistical Analysis

Descriptive analysis was conducted on participant anthropometric and symptomatic data. Independent t-tests assessed difference between groups. A two factor ANOVA (treatment, time) with repeated measures on one factor followed by post hoc least mean squares tests was used to determine differences from baseline to follow-up within and between groups for LEFS, VISA- P, VAS for pain with activity, and jump testing.

Sample size estimation/power analysis

Using the LEFS outcome, based on the effect size in this pilot we found that to determine a difference in these protocols, another study using an alpha = 0.05 and a beta = 0.80, would require a total of 1,134 and 592 participants at 12 and 24 weeks, respectively. Similarly, using the VISA-P outcome 1,468 and 4,228 subjects would be required at 12 and 24 weeks. When we designed this pilot study, we anticipated a larger effect size; therefore, the study was underpowered at 0.058 and 0.053 for the LEFS and the VISA-P at 24 weeks, respectively.

Results

Forty-six participants were screened for inclusion and 31 were enrolled and randomized (17 to the standard-of-care group and 14 to the treatment group; Figure 2). Demographics, anthropometric, and symptomatic baseline data were similar between groups (Table 1). At 12-week follow-up, 2 participants were lost in the SOC and treatment groups. At 24-week follow-up, there were 3 additionally lost in the standard group (30% total loss) and 3 additional in the treatment group (43% total loss). The last known data points were not carried forward with participants lost to follow-up, as the LEFS, VISA-P, and VAS for pain with activity all include elements of pain. If participants were improved and the last known data were carried forward, results could be skewed to underestimate or overestimate progress. Of 31 participants, 14 returned exercise logs. Standard-of-care group returned 5 logs with an average adherence rate of 42.5% of prescribed exercises over 12 weeks. In the treatment group, 9 logs were returned with participants reporting 50% adherence with eccentric squat and 62% adherence with hip muscle strengthening exercises over 12 weeks.

Both groups recorded significantly improved outcome measures of LEFS (standard p = 0.008, treatment p = 0.007) and VISA-P (standard p = 0.001, treatment p = 0.002) over 24 weeks, but no significant differences between groups were observed at 4, 8, 12, or 24 weeks (Tables 2, 3, and 4; Figures 3 and 4). The mean baseline LEFS scores were 57.7 for the SOC group and 54.8 for the treatment group (p=0.53). The mean baseline VISA-P scores were 51.7 for the SOC group and 51.8 for the treatment group (p=0.99). At 12 weeks, the mean LEFS and VISA-P for the SOC group were 66.2 and 67.3 resulting in an 8.5 (p=0.002) and 15.6 (p=0.002) point increase. By 24 weeks, the increase in LEFS from baseline was 9.1 and VISA-P was 18.7 points. At 12 weeks, the mean LEFS and VISA-P for the treatment group were 64 and 63.8 resulting in a 9.2 (p=0.018) and 12.1 (p=0.102) point increase. By 24 weeks, the increase in LEFS from baseline was 9.6 and VISA-P was 20.2 points. Importantly, a direct strength measure such as manual muscle test grading or dynamometry was not measured. These measures could have been correlated with the functional outcome data. This lack of strength data may have limited the study

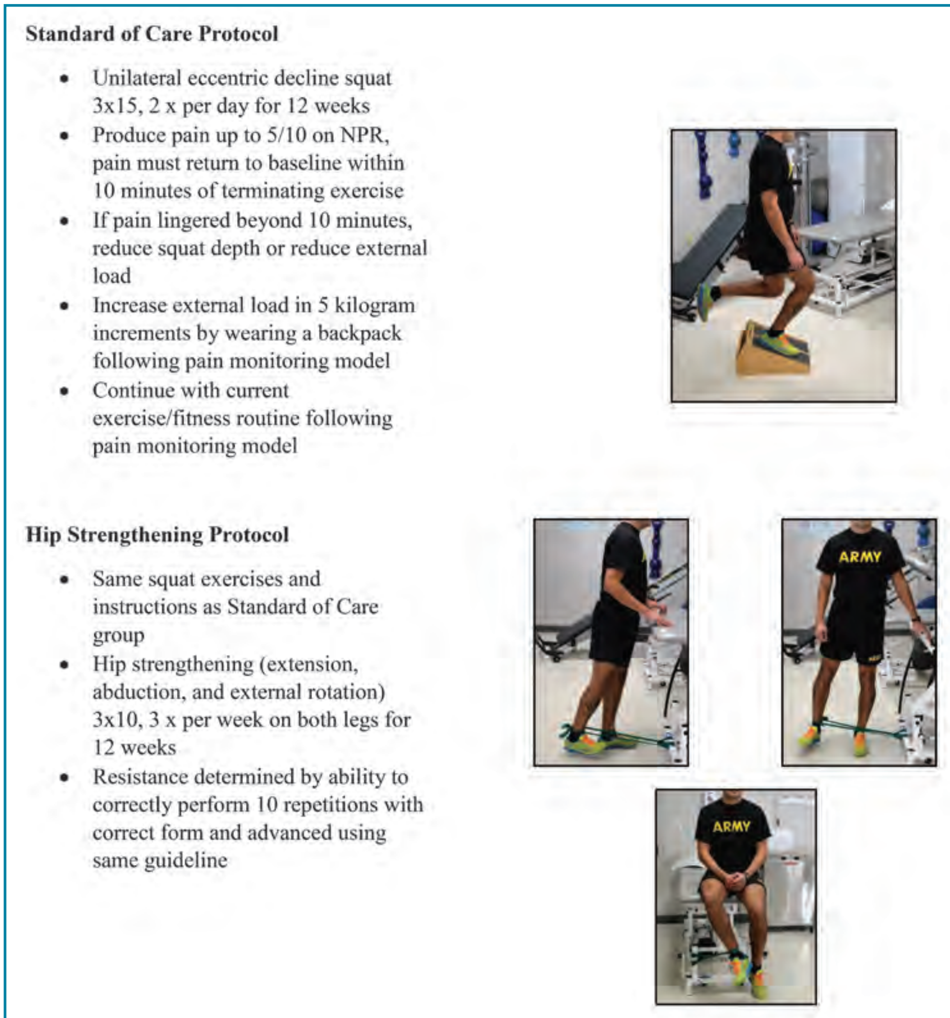

Figure 2. Standard of care and treatment protocols.

Table 1. Participant Characteristics at Baseline (Mean ± SD, Range)

	Standard (n=17)	Treatment (n=14)	p
Age (years)	31.3 ± 5.6 (22.1-38)	26.9 ± 7.4 (19.7-42.3)	0.070
Weight (kilograms)	92.2 ± 13.6 (74.2-132)	88 ± 14.8 (63.4-110)	0.414
Height (centimeters)	178.7 ± 7.8 (164-193)	176.9 ± 10.2 (156-192)	0.573
Symptom duration (months)	6.4 ± 3.3 (3-12)	15.3 ± 22.1 (3-84)	0.111
Average hours in sports per week	7.1 ± 3.5 (3-18)	9.1 ± 3.9 (0-15)	0.146
Average miles ran per week	6.8 ± 5.5 (0-15)	7.9 ± 5.9 (0-16)	0.600
Number of female participants	1	1	
Number with bilateral symptoms	3	4	
Note: Significant at p < 0.05			

findings and interpretation of the data.

The VAS for pain with activity scores were significantly reduced over 24 weeks for the treatment group (p= 0.013) and trended a reduction for the standard group (p = 0.052), but no significant difference between groups were observed at 4, 8, 12, or 24 weeks (Table 4 and 5, Figure 5). Single-leg triple hop distance was not different within or between groups at 4, 8, 12, or 24 weeks. Triple hop distance was significantly different within the standard group between 4 and 12 weeks (p=0.044). Outcomes were similar among and between groups at 4, 8, 12, or 24 weeks (Tables 6-9).

DISCUSSION

In contrast to the original expectation, the present trial showed no favorable effects of combined treatment of eccentric squat and concentric hip muscle strengthening over traditional SOC exercises (eccentric squat) for the treatment of patellar tendinopathy over a 24 week follow-up in an active duty military sample. Outcome measures of LEFS and VISA-P significantly improved in both groups over time. Each group attained minimal clinically important difference (MCID) for each outcome measure at 24 weeks. The LEFS improved by 9.2 points in the SOC group and 9.6 points in the treatment group (MCID 9).[36] The VISA-P scores improved by 18.7 points in the SOC group and 20.2 points in the treatment group (MCID 13).[39] The VAS for pain with activity reduced by 1.3 points in the standard group and 2.2 points in the treatment group (MCID 1.3).[38]

One explanation for lack of improvement with the addition of hip strengthening may be attributed to disproportionate time under tension/load of the patellar tendon potentially impairing recovery. Performance of hip extension and abduction requires a concomitant isometric contraction of the quadriceps muscle, mechanically loading the patellar tendon. Cook et al[18] emphasize appropriate load management to facilitate recovery when managing tendinopathy. Sport specificity of the VISA-P offers another possible reason for lack of significant improvement in the treatment group. Soldiering tasks differ from sporting activities. Using a soldier task-specific outcome measure would likely alter results.

Another potential reason for lack of improvement with hip strengthening may be because hip strengthening does not address kinematic deficits. Patellofemoral literature suggests hip strengthening helps reduce pain and improve function, but does not result in kinematic changes.[40-43] Hip weakness is less pronounced in males than females with patellofemoral syndrome[44]; therefore, strengthening of hip musculature results in the greatest improvements in women.[42] The present study included primarily males. Hip strengthening is likely more appropriate when treating females with this condition.

This is the first study to investigate patellar tendinopathy in a military population and combined hip muscle strengthening with SOC exercises. While the results did not favor one treatment over the other, the treatment group resulted in less reported pain with activity and better improvement in VISA-P scores at 24 weeks. Soldiering tasks place significant stress on the patellar tendon. Army physical readiness training, is conducted 5 days per week,[45] and involves plyometric training, running, agility, and general strengthening activities. Some military occupational specialties require heavy lifting while wearing tactile gear during walking, running, or climbing over varied terrains.[46] The results of this trial offer a feasible intervention in the treatment of patellar tendinopathy.

Review of studies with 24-week follow-up comparing eccentric squat to other methods of treatment for patellar tendinopathy yielded similar results. Kongsgaard et al[12] reported VISA-P change score of 22 points (p < .01) for unilateral eccentric squat group in a study involving recreational athletes comparing corticosteroid injection, heavy slow resistive exercises, and eccentric squats. Bahr et al[22] reported an average VISA-P change score of 29 in both groups (single leg decline eccentric squats and open tenectomy) with a study population of participants reportedly participating in fitness activities. Thijs et al[25]

Table 2. LEFS Within Groups at Time Intervals (Mean ± SD, Range)

Group	Baseline	4 weeks	8 weeks	12 weeks	24 weeks
Standard	n=17	n=17	n=16	n=15	n=12
	57.5 ± 12.1	61.5 ± 10.9	65.5 ± 9.8	66.2 ± 10.3	66.8 ± 9
	(26-74)	(42-79)	(50-79)	(36-78)	(55-80)
		p=0.194	**p = 0.007**	**p=0.002**	**p=0.008**
Treatment	n=14	n=13	n=11	n=12	n=8
	54.8 ± 13	53.6 ±16.7	63.1 ± 13.4	64 ± 14.4	64.4 ± 17.4
	(34-73)	(27-76)	(34-80)	(35-80)	(34-80)
		p=0.775	**p = 0.026**	**p=0.018**	**p=0.007**
Note: p values measured from baseline to respective time, significant at p< 0.05.					

also reported VISA-P change of 19.3 for a group performing single leg decline eccentric squats (N=30). Each of the respective studies were generally similar to the present regarding baseline characteristics.

In this study, exercise adherence was measured by self-reported exercise logs. Of 31 participants, only 14 returned exercise logs. Standard-of-care group had 5 logs returned with an average adherence rate of 42.5%. In the treatment group, 9 logs were returned with participants reporting 50% adherence with eccentric squat and 62% adherence with hip muscle strengthening exercises. With less than half of the participants returning exercise logs, true rates of adherence are unknown. Comparison of previous patellar tendinopathy studies reported exercise adherence rates as 66%[22] and 72%[20]; substantially higher than reported in the present study. Reasons for lack of adherence with log completion or exercise participation is undetermined, but may be attributed to time and complexity. Escolar-Rina et al[47] reported the most common factor to adherence with home exercise program completion was time and complexity of exercises. In the present study, exercises provoked symptoms. Despite extensive education on the desired and necessary response of pain associated with exercise, some participants may still not have complied due to pain. Hip muscle strengthening resulted in greatest exercise adherence. This exercise required no external equipment other than a resistance band, which was provided to each participant. The eccentric squat exercise required participants to construct a 25° decline board. Complexity of exercise equipment may have limited adherence. Additionally, patients with chronic conditions have a tendency to be less adherent to home exercise programs.[48] Both groups had average symptom durations in excess of 6 months.

Limitations

Participants were seen weekly for the first 4 weeks and then as needed based upon participant and therapist discretion. This type of schedule precludes frequent feedback which has been suggested to improve adherence rates.[49,50] Our 50% adherence with eccentric squat and 62% adherence with hip muscle strengthening exercises over 12-week training period may have been a limitation for this study.

Patient satisfaction was not measured. Previous research[12] has favored heavy slow resistive exercise programs with improved patient's satisfaction and exercise adherence over a home-based program as described above. Both programs provide equivocal results. A common theme reported, while not directly measured, was lack of time to complete prescribed exercise programs due to long work hours.

As this was a pilot study, the investigators observed that the overall protocol was

Table 3. VISA-P Within Groups at Time Intervals (Mean ± SD, Range)

Group	Baseline	4 weeks	8 weeks	12 weeks	24 weeks
Standard	n=17	n=17	n=16	n=15	n=12
	51.7 ± 14.2	60.5 ± 11.9	67.1 ± 15.9	67.3 ± 16.1	70.4 ± 18.8
	(28-70)	(41-85)	(44-97)	(42-96)	(47-100)
		p=0.059	p = 0.002	p=0.002	p=0.001
Treatment	n=14	n=13	n=11	n=12	n=8
	51.8 ± 13.7	52.7 ±25.2	59.1 ± 19.8	63.8 ± 25.1	72 ± 28
	(26-73)	(13-96)	(26-94)	(19-97)	(31-100)
		p=0.738	p = 0.393	p=0.105	p=0.002

Note: p values measured from baseline to respective time, significant at p< 0.05

Table 4. Outcome Measures at Time Intervals Between Groups (Mean)

Group	Baseline			4 weeks			8 weeks		
	SOC	Tx	p	SOC	Tx	p	SOC	Tx	p
	n=17	n=14		n=17	n=13		n=16	n=11	
LEFS	57.7	54.8	0.531	61.5	53.6	0.130	65.5	63.1	0.339
VISA-P	51.7	51.8	0.990	60.5	52.7	0.311	67.1	59.1	0.110
VAS	3.9	4.1	0.754	3.7	3.5	0.720	2.5	2.9	0.490

Outcome Measures at Time Intervals Between Groups (Mean)

Measure	12 weeks			24 weeks		
	SOC	Tx	p	SOC	Tx	p
	n=15	n=12		n=12	n=8	
LEFS	66.2	64	0.337	66.8	64.4	0.774
VISA-P	67.3	63.9	0.349	70.4	72	0.840
VAS	2.3	2.9	0.294	2.6	1.9	0.593

Abbreviations: SOC, standard of care: Tx, treatment; LEFS, lower extremity functional scale; VISA-P, Victorian Institute of Sport Assessment – Patella; VAS, visual analog scale

Significant at p< 0.05

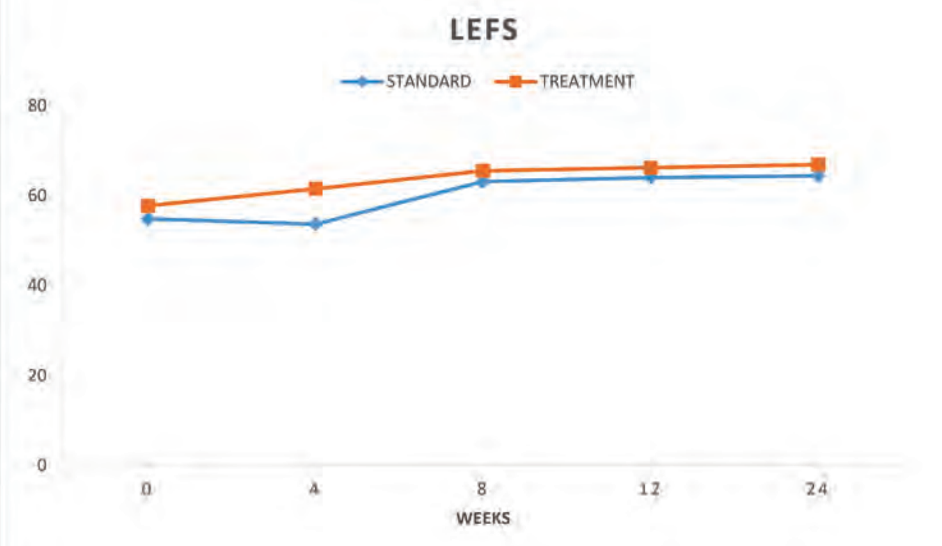

Figure 3. LEFS scores.

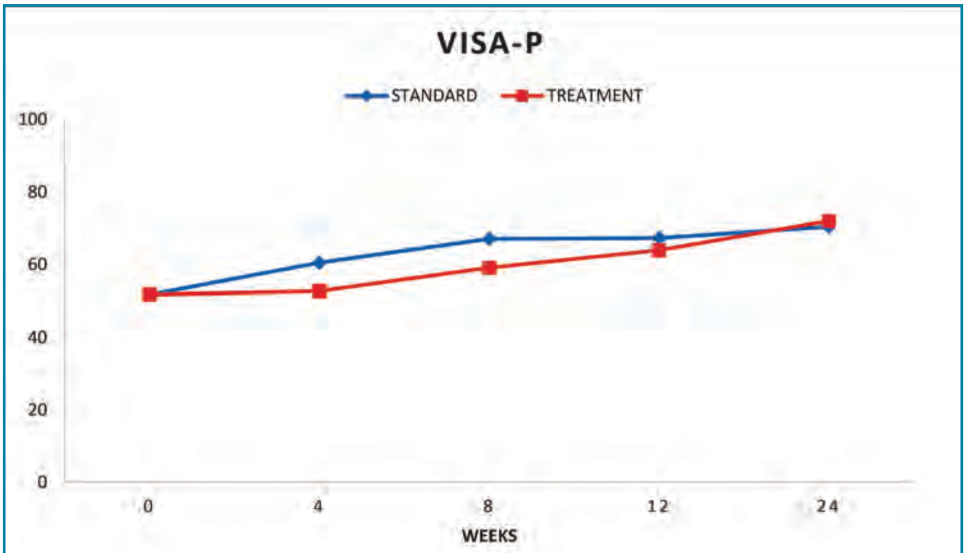

Figure 4. VISA-P scores.

Table 5. VAS for Pain with Activity Within Groups at Time Intervals (Mean ± SD, Range)

Group	Baseline	4 weeks	8 weeks	12 weeks	24 weeks
Standard	n=17	n=17	n=16	n=15	n=12
	3.9 ± 1.7	3.7 ± 1.9	2.5 ± 2.2	2.3 ± 1.8	2.6 ± 2
	(1.2-6.9)	(0.2-6.8)	(0-6.3)	(0-5.9)	(0-5.3)
		p=0.768	**p = 0.035**	**p=0.004**	p=0.052
Treatment	n=14	n=13	n=11	n=12	n=8
	4.1 ± 2	3.5 ±2.3	2.9 ± 2.1	2.9 ± 2.2	1.9 ± 1.9
	(1-7.2)	(1-7.8)	(0-7.7)	(0-6.1)	(0-5.3)
		p=0.265	p = 0.202	p=0.093	**p=0.013**
Note: p values measured from baseline to respective time, significant at p< 0.05					

feasible but, due to an inherent small sample size, generalizations should be viewed with caution. In the military health care environment, long-term follow-up is threatened, specifically at 24 weeks, due to personnel relocation or discontinuation of military service. Steps were taken in the intake process to minimize this risk. Additionally, the same therapist conducted all treatments and collected all outcome measures that introduces bias yet allowed consistency in protocol.

Future research

Systematic reviews[16,51] and expert commentaries[52,53] highlight the need for investigation of nervous system involvement via central or peripheral sensitization along with cortical reorganization for knee pathology. Research should move away from standardized protocols and should be based on clinical guidelines that focus on pain control, tendon remodeling, intrinsic and extrinsic factors, and altered neural function. Tendon remodeling exercises should remain a central component of treatment programs while also addressing regional interdependence. Both intrinsic and extrinsic factors such as biomechanical faults, age, co-morbidities, adiposity, training volume, intensity, and environment must be appropriately addressed to restore functional ability and reduce/minimize risk of repeat injury.[53]

Cook and Purdam[1] proposed 3 stages of tendinopathy. Effort should be made to establish reliable and valid assessment techniques that allow for appropriate classification of each stage. Once each stage can be accurately classified, treatments can be tested for each homogenous subgroup.

CONCLUSION

Similarly favorable effects were demonstrated in military personnel with patellar tendinopathy using either a combined treatment of eccentric squat and hip muscle strengthening or traditional SOC exercises (eccentric squat) over a 24 week follow-up. Outcome measures (LEFS, VISA-P, and VAS for pain with activity) improved similarly in both groups over time. Low enrollment numbers, poor reported exercise adherence, lack of soldier-specific task outcome measure, and loss to follow-up likely affected results. Overall, both groups improved, suggesting either treatment strategy is likely to result in improvements when treating an active duty military population.

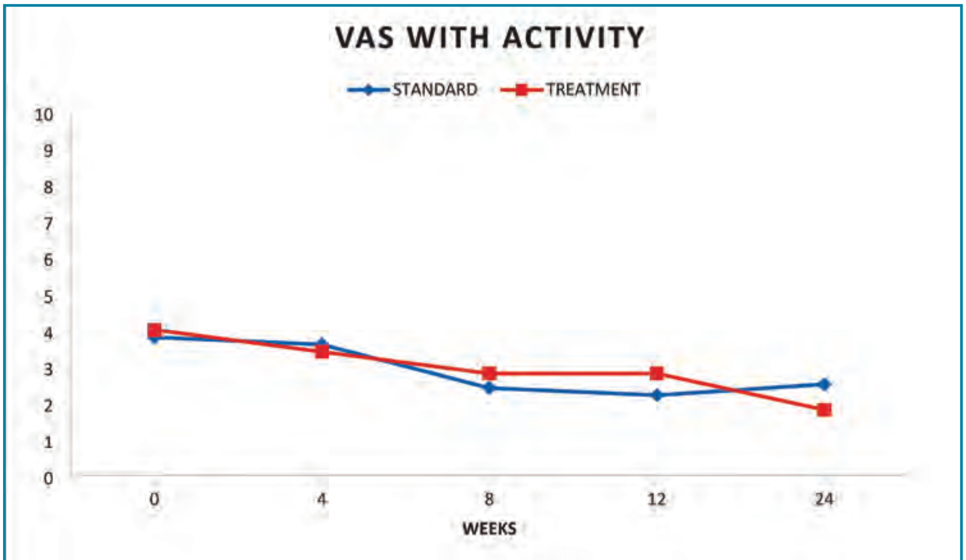

Figure 5. VAS with activity.

Table 6. Single-Leg Triple Hop Involved Within Groups at Time Intervals (Mean ± SD, Range)

Group	Baseline	4 weeks	8 weeks	12 weeks	24 weeks
Standard	n=17	n=17	n=16	n=15	n=11
	1.23 ± 0.3	1.24 ± 0.27	1.3 ± 0.27	1.53 ± 0.28	1.3 ± 0.25
	(0.67-1.79)	(0.7-1.57)	(0.62-1.64)	(0.73-1.79)	(0.97-1.17)
		p=0.719	p = 0.448	p=0.376	p=0.307
Treatment	n=14	n=13	n=11	n=12	n=6
	1.25 ± 0.23	1.25 ± 0.25	1.32 ± 0.27	1.35 ± 0.28	1.4 ± 0.22
	(0.8-1.61)	(0.85-1.57)	(0.92-1.68)	(0.75-1.73)	(1.1-1.58)
		p=0.776	p = 0.665	p=0.418	p=0.454
Note: distance measured in meters, p values measured from baseline to respective time, significant at p< 0.05					

Table 7. Single-Leg Triple Hop Uninvolved Within Groups at Time Intervals (Mean ± SD, Range)

Group	Baseline	4 weeks	8 weeks	12 weeks	24 weeks
Standard	n=17	n=17	n=16	n=15	n=11
	1.28 ± 0.31	1.27 ± 0.25	1.3 ± 0.23	1.26 ± 0.21	1.3 ± 0.23
	(0.77-1.79)	(0.73-1.57)	(0.8-1.58)	(0.8-1.62)	(0.95-1.67)
		p=0.930	p = 0.446	p=0.889	p=0.279
Treatment	n=14	n=13	n=11	n=12	n=6
	1.31 ± 0.27	1.32 ± 0.24	1.36 ± 0.27	1.38 ± 0.29	1.46 ± 0.12
	(0.64-1.62)	(0.78-1.71)	(0.88-1.76)	(0.71-1.78)	(1.25-1.58)
		p=0.392	p = 0.320	p=0.330	p=0.150
Note: distance measured in meters, p values measured from baseline to respective time, Significant at p< 0.05					

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Table 8. Triple Hop Involved Within Groups at Time Intervals (Mean ± SD, Range)

Group	Baseline	4 weeks	8 weeks	12 weeks	24 weeks
Standard	n=17	n=17	n=16	n=15	n=11
	4.21 ± 0.81	4.29 ± 0.84	4.54 ± 0.85	4.5 ± 0.83	4.33 ± 0.77
	(2.62-5.74)	(1.86-5.29)	(2.38-5.77)	(2.59-6.06)	(3.1-6)
		p=0.875	p = 0.071	p=0.084	p=0.291
Treatment	n=14	n=13	n=11	n=12	n=6
	4.24 ± 0.73	4.39 ± 0.79	4.61 ± 0.89	4.56 ± 0.82	4.69 ± 0.54
	(2.61-5.28)	(3.02-5.97)	(3.22-6.23)	(2.83-6.01)	(3.91-5.26)
		p=0.570	p = 0.104	p=0.264	p=0.281

Note: distance measured in meters, p values measured from baseline to respective time, Significant at p< 0.05

Table 9. Triple Hop Uninvolved Within Groups at Time Intervals (Mean ± SD, Range)

Group	Baseline	4 weeks	8 weeks	12 weeks	24 weeks
Standard	n=17	n=17	n=16	n=15	n=11
	4.28 ± 0.81	4.34 ± 0.73	4.46 ± 0.76	4.41 ± 0.78	4.29 ± 0.85
	(2.83-5.84)	(2.51-5.35)	(2.54-5.59)	(2.68-5.64)	(2.99-5.96)
		p=0.340	p = 0.106	p=0.253	p=0.482
Treatment	n=14	n=13	n=11	n=12	n=6
	4.33 ± 0.79	4.41 ± 0.72	4.49 ± 0.81	4.52 ± 0.87	4.77 ± 0.31
	(2.27-5.44)	(2.64-5.51)	(2.93-5.9)	(2.5-6.08)	(4.36-5.28)
		p=0.483	p = 0.395	p=0.702	p=0.540

Note: distance measured in meters, p values measured from baseline to respective time, Significant at p< 0.05

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