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Return to Running After Achilles Tendon Repair: How Do US Navy Service Members' Physical Readiness Tests Change After Undergoing an Achilles Tendon Repair?

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Abstract

Background Achilles tendon ruptures are common injuries among adults that can cause substantial pain and disability. While prior studies have reported on return-to-play rates in athletes, limited data exist regarding functional outcomes in both runners and within a military population; such data may also help inform care for active civilian patients.

Questions/purposes (1) How do US Navy service members undergoing Achilles tendon repairs perform on the cardiovascular section of their physical readiness test preoperatively compared with postoperatively? (2) How do US Navy service members undergoing Achilles tendon repairs perform on the cardiovascular section of their physical readiness test on consecutive postoperative physical readiness tests?

Methods This was a retrospective analysis of data from 2014 to 2020 from the outpatient Military Health System Medical Data Repository and Physical Readiness

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Information Management System. Achilles tendon rupture was identified using a procedure code from the Medical Data Repository (code 27650). The Physical Readiness Information Management System has electronic records of all the physical readiness tests completed by Navy personnel. As such, the study was limited to Navy personnel. The study cohort included 1057 Navy personnel who sustained an Achilles tendon rupture and underwent operative repair. Service members who underwent more than one operative repair during the study period (9.8% [104 of 1057]) were excluded. Another 41.7% (441 of 1057) were excluded for not having a valid cardiovascular physical readiness test within 30 to 730 days before or 90 to 730 days after operative repair. Forty-three percent (451 of 1057) of Navy personnel were included in the analyzed cohort. These service members underwent one Achilles tendon repair and had cardiovascular physical readiness test assessments from before and after the operative repair. The cardiovascular component was stratified into four subgroups: individuals who biked before and after Achilles tendon rupture (35% [156 of 451]), those who ran (28% [127]), those who ran before Achilles tendon rupture but transitioned to another cardiovascular test after operative repair (32% [144]), and those who performed an alternative cardiovascular test (5% [24]). Cardiovascular assessments performed 30 to 730 days before were utilized to capture all patients who had completed an assessment within the 2 years prior to sustaining the Achilles tendon rupture. Postoperatively, cardiovascular assessments would not typically be recommended by the orthopaedic surgeon until at least 90 days after the procedure. Postoperative cardiovascular assessments were included up to 2 years postoperatively to evaluate initial performance after surgical repair and subsequent performances if numerous physical readiness tests were completed after the repair. The study cohort was predominantly male (94.4%) with a mean age of 33 years. Differences in physical readiness test scores before and after Achilles tendon repair for the bike and run subgroups were compared while adjusting for age, time since procedure, and sex. Changes in physical readiness test categories before and after Achilles tendon rupture were evaluated by converting the categories into discrete scores (outstanding = 5, excellent = 4, good = 3, satisfactory = 2, probationary = 1, failure = 0) and using a paired t-test for all cardiovascular subgroups. For example, a US Navy male age 30 to 35 years would receive an outstanding (discrete score = 5) if his 1.5-mile run time was < 10 minutes, while he would receive a failure, discrete score of 0, if his 1.5-mile run time was > 14 minutes and 30 seconds. The proportions of individuals who improved, decreased, or maintained fitness categories were reported. The analysis described was repeated for a subgroup of individuals who completed two postoperative cardiovascular physical readiness tests.

Results We found that individuals performed worse on their physical readiness tests after Achilles tendon rupture compared with their preinjury scores for the biking subgroup (10 seconds; $p = 0.02$) and the 1.5-mile running subgroup (41 seconds; $p < 0.001$). When analyzing the changes in fitness category levels, there was no difference for the biking subgroup. Eighty-five percent (132 of 156) of individuals maintained or improved their physical readiness test scores after Achilles tendon rupture for the biking subgroup, in contrast to 74% (106 of 144) for the run-to-another subgroup and 69% (88 of 127) for the running subgroup. There were between 0% (0) and 1.5% (2) first-time physical readiness test failures after Achilles tendon repair. Last, 165 members underwent additional analysis with two postoperative physical readiness test scores available for the biking and running subgroup. Participants improved their running scores (18 seconds; $p = 0.004$) but not their biking scores.

Conclusion Our findings can help orthopaedic surgeons to counsel active individuals, especially male runners. Runners undergoing Achilles tendon repair may run more slowly (approximately 41 seconds on a 1.5-mile run); however, these times will tend to improve over time even 1 year after Achilles tendon repair. Still, numerous unanswered questions remain regarding whether these changes in run times persist when compared with nonoperatively treated Achilles tendon ruptures, the specific type of surgical procedures performed, and the postoperative protocol utilized, which are all avenues for future research.

Level of Evidence Level III, therapeutic study.

Introduction

Achilles tendon ruptures are serious musculoskeletal injuries that disproportionately affect physically active individuals, including competitive athletes and military service members [3, 4]. These injuries are associated with considerable morbidity and functional impairment, particularly in populations whose occupations demand high levels of physical performance. The incidence of Achilles tendon rupture has been reported to be higher in the US military than the general population [3]. These injuries have been demonstrated to lead to substantial functional decline in military members requiring approximately 6.7 months to return to full, unrestricted duty after surgical repair [3, 6]. The same may be true for active individuals, perhaps including recreational athletes and individuals such as police officers and firefighters, who experience these injuries.

Despite numerous studies evaluating return to play in athletes, functional recovery in active populations, especially those with physically demanding careers, are less well characterized [2, 5, 10]. A few studies noted that Achilles tendon ruptures are potentially disastrous and can be career ending for the competitive athlete with return to play dependent upon position [1, 2, 9].

There is a lack of research evaluating long-term functional performance after Achilles tendon repair in physically

active populations. Previous studies have evaluated functional outcomes after Achilles tendon repair utilizing metrics such as plantarflexion strength and maximal heel-rise height. However, no studies have examined standardized, objective metrics of functional capacity—such as the cardiovascular component of the US Navy's physical readiness tests before and after Achilles tendon repair [7, 8]. This objective metric offers a unique opportunity to quantify functional outcomes and performance. Understanding these functional outcomes has implications for military readiness, as well as for the care of other active individuals, such as firefighters, police officers, and recreational athletes. These populations share similar physical demands and recovery goals. Clarifying these functional outcomes may improve counseling, help guide rehabilitation strategies, and support realistic patient expectations for return to function.

We therefore asked: (1) How do Navy service members undergoing Achilles tendon repairs perform on the cardiovascular section of their physical readiness test preoperatively compared with postoperatively? (2) How do US Navy service members undergoing Achilles repairs perform on the cardiovascular section of their physical readiness test on consecutive postoperative physical readiness tests?

Patients and Methods

Study Design and Setting

This was a retrospective analysis of data from 2014 to 2020 from the Military Health System Medical Data Repository and Physical Readiness Information Management System. All outpatient electronic medical data—including Comprehensive Ambulatory/Professional Encounter Record Basic and Enhanced, MHS GENESIS, and TRICARE Encounter Data Non-Institutional—of the service members included were retrieved from 2014 to 2020. These datasets are the only electronic medical records for the military that have outpatient diagnostic and procedure information on all Navy service members. Individuals with Achilles tendon repair were identified using a procedure code from the Medical Data Repository (code 27650). Electronic demographic data from VM6 Beneficiary Level were pulled for individuals with the Achilles tendon repair procedural code. The Physical Readiness Information Management System has electronic records of all the physical readiness tests completed by Navy personnel. As such, the study was limited to Navy personnel.

Participants

A total of 1057 Navy personnel underwent Achilles tendon repair during the study period. Service members who underwent more than one operative repair during the study period (9.8% [104]) were excluded to reduce bias in postoperative physical readiness test outcomes. Multiple surgeries could confound results by introducing overlapping recovery periods, making it difficult to isolate the impact of operative repair on physical readiness test performance. Among the 953 personnel with one operative repair, 93.6% (892) had at least one valid cardiovascular physical readiness test. Another 49.4% (441 of 892) were excluded for not having a physical readiness test within 30 to 730 days before or 90 to 730 days after operative repair.

Descriptive Data

The final study cohort for the primary objective was comprised of 451 individuals who underwent a single Achilles tendon repair and who had cardiovascular physical readiness test assessments both before and after operative repair within appropriate timelines. The study cohort was predominantly male (94.4%) with a mean age of 33 years. The cardiovascular component was stratified into four subgroups: 35% (156 of 451) of individuals who biked before and after Achilles tendon repair, 28% (127) of those who ran, 32% (144) of those who ran before Achilles tendon repair but transitioned to another cardiovascular test after operative repair, and 5.3% (24) who participated in an alternative cardiovascular event. The secondary objective looked at a subgroup of the 451, namely 36.6% (165) of individuals who completed two postoperative physical readiness tests. As before, the preoperative physical readiness test was within 30 to 730 days before Achilles tendon repair, the first postoperative physical readiness test was within 90 to 730 days, and the second postoperative physical readiness test was within 730 days after the first postoperative physical readiness test.

The cardiovascular component for the primary objective was stratified into four subgroups: 34.6% (156 of 451) of individuals who biked before and after Achilles tendon repair (bike-to-bike), 28.2% (127) of those who ran (run-to-run), 31.9% (144) of those who ran before Achilles tendon repair but transitioned to another cardiovascular test after operative repair (run-to-another), and 5.3% (24) who performed an alternative cardiovascular test. The bike-to-bike group was older (mean ± SD 35 ± 7 years) compared with the run-to-run (31 ± 6) and run-to-another (32 ± 7) groups. All groups had a similar proportion of males and similar amount of time in days since procedure. For the secondary objective, the subgroup comprised 165 service members who biked (56.4% [93]) at all three time points (namely, before physical readiness test, first after physical readiness test, and second after physical readiness test) or who ran (43.6% [72]).

The data set did not allow us to assess the location of the Achilles tendon tear (for example, whether the tear was insertional or midsubstance), and so we surmise that the

data set applies to a group of patients with a variety of common tear locations who underwent repair.

Primary and Secondary Study Outcomes and Variables

Our primary study goal was to evaluate cardiovascular event time before and after Achilles tendon repair. To do this, we evaluated changes in physical readiness test performance categories before and after Achilles tendon repair. Raw cardio scores (seconds to complete the 1.5-mile run) were extracted for the bike-to-bike and run-to-run subgroup for the physical readiness tests both before and after Achilles tendon repair. As raw scores (run times in seconds versus bike times) are not directly comparable because of differences in cardiovascular type and scoring criteria, only individuals with the same cardiovascular modality were compared with one another. In addition to comparing raw cardiovascular event scores, we also converted the performance categories assigned by the Navy into discrete numeric scores to enable standardized comparisons across test types. Specifically, physical readiness test performance categories were assigned to the following discrete scores: outstanding = 5, excellent = 4, good = 3, satisfactory = 2, probationary = 1, and failure = 0. These categorical ratings are standardized for age and sex, allowing comparison across different cardiovascular modalities such as the run and bike. Therefore, a change from a lower to a higher category (for example, satisfactory to good) was interpreted as an improvement in cardiovascular fitness, whereas a decrease (for example, excellent to good) was interpreted as a decline. No change in category was considered maintenance of fitness level. The proportions of individuals who improved, decreased, or maintained fitness categories were reported for all three subgroups: bike-to-bike, run-to-run, and run-to-another.

Our secondary study goal was to evaluate whether individuals were able to improve on their cardiovascular events on subsequent physical readiness tests. For this objective, we looked at the subgroup of individuals (n = 165) who completed two postoperative physical readiness tests for either the bike or run modality. This allowed for a longitudinal analysis on changes in cardiovascular physical fitness scores over time. Cumulative changes in cardiovascular performance times, defined as the difference in raw cardiovascular scores (seconds) relative to the preoperative baseline, were calculated at the first and second postoperative assessment.

Ethical Approval

We obtained ethical approval for this study from the Naval Health Research Center Institutional Review Board (protocol number NHRC.2003.0025).

Statistical Analysis

For the primary objective (looking at one postoperative physical readiness test), we compared the raw cardiovascular test scores before and after Achilles tendon repair for the bike-to-bike (35% [156 of 451]) and run-to-run (28% [127]) subgroups. The Shapiro-Wilk test indicated that preoperative physical readiness tests were normally distributed for the bike-to-bike and run-to-run subgroups (all p values > 0.05). Given normality, a paired t-test was used to evaluate change in cardiovascular fitness of the raw scores. A linear regression model was used to estimate the mean change in physical readiness test scores before and after Achilles tendon repair, while adjusting for age, sex, and time since procedure. Although this was a within-subject analysis, adjustment for covariates was performed to examine whether these factors modified the magnitude of change. Last, a chi-square test was used to look at the proportions of individuals who improved, declined, or maintained physical readiness test performance categories. As failures on the physical readiness test can impact discharge from service and promotions, the proportion of individuals who failed the cardiovascular section of the physical readiness test after Achilles tendon repair was also reported.

For our second objective (looking at two postoperative physical readiness tests), we employed a linear mixed-effects model to examine the longitudinal changes in cardiovascular physical fitness scores. The physical readiness test score (that is, run or bike time in seconds) was the dependent variable, and the time point (preoperative physical fitness test, first or second postoperative physical fitness test) was a categorical fixed effect. The cumulative changes in cardiovascular performance times across repeated physical readiness tests were plotted to visualize trends over time. Separate trajectories were plotted for participants completing the run and bike modalities.

Results

Cardiovascular Event Times (Before Versus After Repair)

When analyzing the raw cardiovascular scores of the physical readiness test, individuals performed worse for both the bike-to-bike subgroup (mean ± SD preoperative 12:40 ± 0:56 minutes versus postoperative 12:50 ± 1:03 minutes, mean difference 10 seconds [95% confidence interval (CI) 2 to 17]; p = 0.02) and the run-to-run subgroup (mean ± SD preoperative 11:12 ± 1:12 minutes versus postoperative 11:53 ± 1:34 minutes, mean difference 41 seconds [95% CI 30 to 52]; p < 0.001) using a paired t-test. In adjusting for age, sex, and time since procedure, none of these covariates was associated with cardiovascular

performance outcomes for either subgroup. When looking at the change in performance categories on all three cardiovascular subgroups, individuals in the bike-to-bike group had a higher proportion of maintaining performance category (75%) when compared with the run-to-run (59%) and run-to-another (58%) subgroups (p = 0.002) (Table 1). Individuals in the run-to-run subgroup, on the other hand, had a higher proportion of decreasing their performance category (31%) compared with the bike-to-bike (15%) and run-to-another (26%) subgroups (p = 0.007). After Achilles tendon repair, 1% (1) of individuals in the bike-to-bike subgroup failed the cardiovascular portion of the physical readiness test, 2% (2) in the run-to-run subgroup, and 0% (0) in the run-to-another subgroup (p = 0.30).

Cardiovascular Event Times (on Consecutive Physical Readiness Tests)

When looking at a subgroup of individuals with two postoperative physical readiness tests, there were a few notable changes. Individuals performed worse on their first postoperative physical readiness test compared with preoperative scores for both the run (mean difference 47 seconds [95% CI 35 to 59]; p < 0.001) and bike (mean difference 14 seconds [95% CI 5 to 24]; p = 0.005) groups. However, by the second postoperative physical readiness test, the running group had an improvement in running times compared with their first postoperative scores (mean difference 18 seconds [95% CI 0 to -35]; p = 0.004), whereas the biking group did not (mean difference 1 second [95% CI -12 to 14]; p = 0.78) (Fig. 1).

Discussion

Achilles tendon ruptures lead to notable functional limitations, especially in active populations such as competitive athletes and military personnel [3, 4]. While return-to-play studies in athletes are common, there is limited research on functional recovery after Achilles tendon repair in active populations and in those with physically demanding careers. The use of standardized metrics, such as the US Navy's physical readiness tests, provided a valuable opportunity to evaluate functional outcomes. Our findings align with prior studies suggesting that Achilles tendon ruptures may have prolonged functional consequences in populations with high physical demands [1, 2, 6]. The use of the physical readiness test provided an objective, standardized, and occupation-relevant measure of functional capacity, allowing for a more granular understanding of recovery over time. The observed decline in cardiovascular performance supports existing evidence that even after surgical repair, patients may experience lasting deficits in strength, endurance, or mobility. Furthermore, the gradual improvement seen in subsequent run scores highlights the potential for continued recovery beyond 1 year, suggesting that extended rehabilitation may be beneficial.

Limitations

This study had several limitations, including inability to pursue further analysis based on nonoperative versus operatively managed Achilles tendon ruptures, type of Achilles tendon repair surgical technique, or postoperative protocol followed. A large number of patients (n = 441) were excluded because physical readiness test results were not available for analysis. This group may have included patients who were not doing as well as those who returned to performing physical readiness tests, and it may have included patients who received a medical waiver for their Achilles tendon repair or individuals who left the military because of this injury. The population excluded from this study was large, and this may have altered the results.

Table 1. Descriptive data and key findings

Characteristic	Bike-to-bike (n = 156)	Run-to-run (n = 127)	Run-to-another (n = 144)	p value
Age at procedure in years	35 ± 7	31 ± 6	32 ± 7	< 0.001
Time since procedure in days	287 ± 118	298 ± 109	272 ± 108	0.80
Men	94 (146)	95 (121)	95 (137)	0.78
Improved categories	10 (15)	10 (13)	16 (23)	0.18
Same categories	75 (117)	59 (75)	58 (83)	0.002
Decreased categories	15 (24)	31 (39)	26 (38)	0.007
Failed physical readiness test	1 (1)	2 (2)	0 (0)	0.30

Data presented as mean ± SD or % (n). Means compared using t-tests, proportions compared using chi-square. Navy physical readiness cardiovascular test categories are divided into 5 levels; these categories were converted into discrete scores for analysis (outstanding = 5, excellent = 4, good = 3, satisfactory = 2, probationary = 1, failure = 0). For example, a male age 30 to 35 years, an outstanding 1.5 mile run was < 10 minutes, while failure was > 14 minutes and 30 seconds.

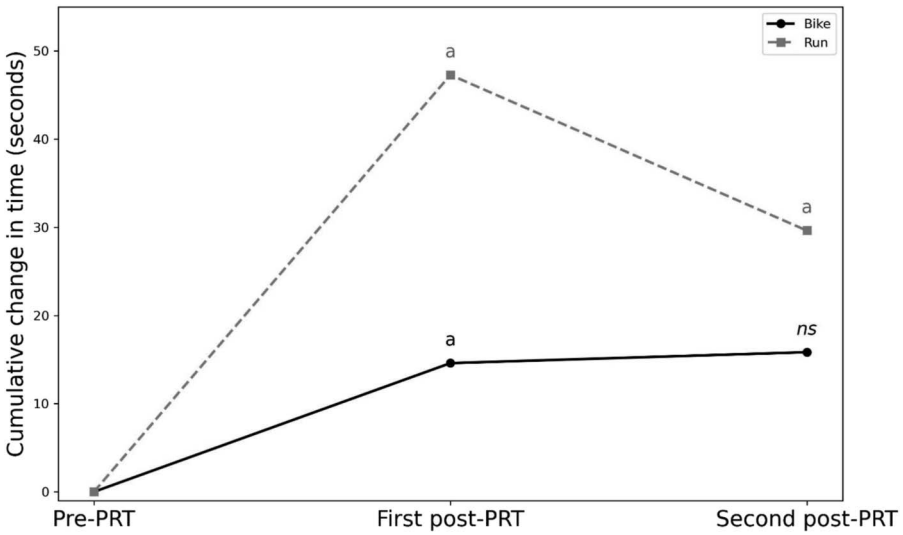

Fig. 1 This graph demonstrates the cumulative change in time for the physical readiness test (PRT) from before Achilles repair to after Achilles repair. The running subgroup improved their time (18 seconds; p = 0.004) on their second PRT after surgery; however, this was still slower than the preinjury PRT results. [a]Significant change in time ($p < 0.05$) from the PRT score before Achilles repair. ns = no significance.

Additionally, the composition of our patient cohort—primarily young men on active duty in the Navy—may have limited the generalizability of our findings. No analysis was able to be performed regarding the functional demands of these service members based on job type. This study was unable to analyze if service members were combat, combat support, or noncombatant which would imply baseline fitness and motivation to return to prior job type at the time of injury. Therefore, the results of our study likely are generalizable to a civilian cohort of young, active, male individuals who desire to return to running or cycling after an Achilles tendon repair. Because of the predominantly male study cohort, we could not perform further analysis into differences of sex. These findings may not be translatable to female runners and cyclists.

Physical Readiness Test Scores Declined After Achilles Tendon Repair in the Running Group

We found a notable decline in physical readiness test scores after Achilles tendon repair in US Navy service members, which was particularly evident in running performance. Both biking and running subgroups experienced increased times after repair. Remarkably, only 69% (88 of 127) of individuals managed to maintain or improve their running scores. Moreover, a large proportion, 32% (144), transitioned from running to alternative cardiovascular tests after operative intervention, underscoring the multifaceted impact of this injury and its management. Comparable with prior evidence indicating variable return-to-play rates across different sports, our data corroborate a range (69% [88 of 127] to 85% [132 of 156]) of individuals showing sustained or improved physical readiness test scores after Achilles tendon repair across all subgroups, which aligns closely with existing findings [1, 5].

Conclusion

In light of our findings, orthopaedic surgeons can more effectively counsel active individuals, including recreational male runners and cyclists, as well as those with physically active careers (such as firefighters and police officers) that they may run about 40 seconds more slowly on a 1.5-mile run. However, it is important to emphasize to patients that these results improve, with continued gains seen even 1 year after Achilles tendon repair. This reinforces that recovery is an extended process, and patients should be encouraged to remain optimistic and engaged in rehabilitations to continue to improve long-term functional outcomes. As a result of these findings, our practice places greater emphasis on setting realistic expectations and timelines both preoperatively and early in the recovery process. It is important to highlight the potential for ongoing improvement beyond the initial 12-month postoperative period. Numerous unanswered questions remain regarding whether these changes in run times persist when compared with nonoperatively treated Achilles tendon ruptures, the specific type of surgical procedures

performed, and the postoperative protocol utilized. Because of challenges and limitations of randomized controlled trials, particularly attributed to patient selection for treatment, as well as variety in surgical practices, future research should include large, well-designed prospective cohort studies and registry-based data that can help address which tear types, surgical techniques, and rehabilitation strategies may most effectively restore high levels of function in active populations.

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