

Original Research

Comparing Quantification Methodologies for the Single-Leg Heel-Rise in Patients Following Operative and Non-Operative Management for Achilles Tendon Rupture

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Background

The Single-Leg Heel-Rise test (SLHR) is commonly used to determine the functional status of patients following Achilles tendon rupture (ATR). Several methods exist to quantify performance variables during the SLHR including repetition counting, linear position transducers (LPT) and motion capture/analysis systems; however, they have not been directly compared following operative or non-operative management of ATR. Hypothesis/Purpose: The purpose of this study was to compare three methods to quantify repetition number, heel-rise height, and total work during the SLHR test in patients managed either operatively or non-operatively for ATR.

Study Design

Cross-sectional study

Methods

Twenty-four patients who underwent either operative or nonoperative treatment for complete ATR completed SLHR to failure on a 10° angle board. LPT, two-dimensional motion capture, and the Calf Raise smartphone application recorded heel-rise repetitions and height. Intraclass correlation coefficients and Bland-Altman plots (95% limits of agreement) compared devices. Work was reported as absolute values and limb symmetry index. Two-way analyses of variance were completed for all variables.

Results

In this sample of 17 males and 7 females (operative [n=12; 39.0±8.9 years; 9 male] and non-operative [n=12; 46.2±14.1 years; 8 male] groups) strong, positive correlations were demonstrated between all devices, with the highest occurring between motion capture and the app ($r^2 = 0.997$). Bland-Altman Limits of Agreement showed wide limits of agreement across all methods. Peak and accumulated heel-rise height was reduced on the affected limb when measured by all devices, translating to reduced affected limb total work (mean difference: motion capture -403.5 Joules [J] (95%CI -41.5–902.6), app -434.7 J (95%CI -924.3–54.8), and LPT -370.4 J (95%CI -802.6–61.9).

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Conclusion

LPT, motion capture, and the calf raise app can be used to quantify repetitions, work, and heel-rise height in patients following ATR. However, device values should not be used interchangeably due to wide limits of agreement across methodologies.

Level of Evidence

Level 2c

INTRODUCTION

Assessment of patients' functional abilities following Achilles tendon rupture (ATR) has been done using various techniques including, but not limited to, isokinetic and isometric strength testing, various heel-rise tests, unilateral countermovement jumps and patient reported outcome measures.¹⁻⁴ These techniques each provide unique information regarding the patient's functional abilities; including muscle strength deficits, dynamic performance, as well as subjective experiences and functional limitations. The Single-Leg Heel-Rise (SLHR) test is commonly used to assess ankle function due to the relative simplicity of the test and minimal equipment required.⁵⁻⁸

The SLHR is an endurance test where individuals perform unilateral heel-rises until failure, or until they are unable to maintain frequency or minimum heel rise height,^{5, 8-12} and is a reliable and valid test often used by clinicians to assess strength and endurance.^{5,13} In previous literature,^{14,15} the SLHR assessment was based on the total number of heel-rises completed in unilateral stance on each limb¹²; however, the accumulated number of repetitions is limited in its ability to detect performance differences between limbs in patients after ATR. Total work, the product of total body weight and distance moved, completed during the test may provide more insight to performance deficits when total repetitions are comparable.^{5,16}

Silbernagel et al. introduced the use of a linear encoder for the SLHR, where a string was attached from the device to the rear sole of the participant's shoe,⁵⁻¹¹ allowing for the quantification of total repetitions, total work, and heel-rise height. It has been suggested that heel-rise height may be a critical component for assessing the end range of plantar flexion strength.¹⁷ Therefore, including this measure may improve the sensitivity of the SLHR test during assessments.⁵

Recently, the Calf Raise smartphone application was developed by Dr. Hébert-Losier from the University of Waikato¹⁸ as a cost-effective alternative to the linear position transducer (LPT).¹⁸ This methodology uses a smartphone camera and reflective marker placed on the patient's heel. Previous work has validated the app in measuring repetitions, work (force*distance), total and peak height, fatigue index (how quickly fatigue develops), and peak power (maximum work rate) compared to three-dimensional motion capture and force plates.^{18,19} Additionally, concurrent validity has been demonstrated against a linear position transducer in total concentric work.²⁰ Like the linear position transducer, motion capture cameras and software can be expensive and may not be feasible in a clinical setting.

Therefore, this application may be a cost-effective alternative to assess patients' recovery.

The purpose of this study was to compare three methods to quantify repetition number, heel-rise height, and total work during the SLHR test in patients managed either operatively or non-operatively for ATR.

MATERIAL AND METHODS

PARTICIPANTS

This was a retrospective cohort with a single evaluation completed prospectively, with comparative analyses of patient outcomes reported previously.²¹ Participants were eligible for inclusion if they were between the ages of 18-65 years, had undergone treatment for a complete ATR between October 2014 and 2019 and were treated either operatively or non-operatively within three weeks of the initial injury. Patients were excluded if they had re-ruptured their Achilles tendon since the index injury, had an ATR on their contralateral leg, or had any significant ankle, knee or medical comorbidities that prevented completion of the functional test. A total of 24 patients who had either operative or non-operative management participated in the study. All participants provided informed consent prior to data collection and procedures were approved by the Institutional Review Board of the University of Manitoba (HS22439 (B2018:136)).

PROCEDURES

SLHR was recorded using LPT (GymAware LE; Kinetic Performance; Braddon ACT, Australia), two-dimensional motion capture (Myovideo, Noraxon, U.S.A Inc.; Scottsdale, AZ, USA), and the Calf Raise app (version 3.06; Hamilton, New Zealand), during a single trial.^{18,19,22} Patients were barefoot with the LPT anchored to their heel via an ankle strap and tape to hold the position constant. A reflective marker for the motion capture and Calf Raise app was positioned inferior to the lateral malleolus, as instructed by the app. Patients were positioned standing on one leg at a time on a 10° angle board. To maintain balance, patients were instructed to apply light, finger-touch pressure to a wall. Patients completed repetitive plantar flexion to a metronome set to a tempo of 1-0-1-0, (i.e., 60 beats per minute [bpm] or 30 heel-rises in one-minute) and were instructed to go as high as they could for each repetition. The test was terminated when the patient voluntarily stopped due to fatigue, was no longer able to maintain the prescribed tempo, or completed a technical error (i.e., knee flexion, lowering other parts of the body while raising the

Table 1. Patient Demographics

	Operative Treatment (n=12)	Non-Operative Treatment (n=12)	Group (N=24)
Age (yrs)	39.0 ± 8.9	46.2 ± 14.1	42.6 ± 12.3
Age at injury (yrs)	35.3 ± 9.1	43.0 ± 13.6	39.2 ± 12.2
Follow-up interval (yrs)	4.1 ± 1.4	3.3 ± 1.2	3.7 ± 1.3
Sex - no. (% male)	9 (75.0)	8 (66.7)	17 (70.8)
Height (cm)	175.7 ± 8.4	174.1 ± 7.8	174.9 ± 8.0
Weight (kg)	89.7 ± 14.8	94.4 ± 22.5	92 ± 18.8
Body mass index	29.3 ± 5.4	31.3 ± 8.0	30.3 ± 6.9
Injury to right limb -no. (%)	5 (41.7)	4 (41.7)	10 (41.7)
Smoker - no. (%)	1 (8.3)	2 (16.7)	3 (12.5)

Patient demographics. Data are represented as mean ± standard deviation. cm= centimeters; kg= kilograms.

foot, loss of contact with portions of the forefoot with the ground). The number of completed repetitions and total height completed across all repetitions was recorded for all three devices. Work⁵ was calculated for each limb and expressed as absolute values per limb and limb symmetry index (LSI; affected limb / unaffected limb * 100%).

DATA PROCESSING

Video used for both the Calf Raise app and motion capture software was recorded with a NiNOX 125 camera (Noraxon, U.S.A Inc.; Scottsdale, AZ, USA) at rate of 120 fps. The video was imported into the Calf Raise app where it was post-processed and provided total heel-rise height and work. Motion capture processing was completed using two-dimensional vertical tracking of the ankle marker, resulting in the output of number of repetitions and individual repetition heights. LPT data was recorded using the GymAware app (Kinetic Performance, Braddon ACT, Australia), with exported files showing number of repetitions and height of each repetition.

STATISTICAL ANALYSIS

Data from each device were reported as mean and standard deviation where appropriate. Two-way analyses of variance (ANOVAs; Group: Operative, Non-operative; Side: Affected, Unaffected) were completed for all test metrics. Intraclass correlation coefficients (ICC) were used to determine the degree of correlation between measurement devices and Bland Altman Plot with 95% limits of agreement were determined across all devices. ICCs were interpreted as 0.49 poor, 0.5-0.74 moderate, 0.75-0.89 good, and ≥ 0.9 excellent,²³ and correlation coefficients as: 0.10-0.39 weak, 0.4-0.69 moderate, 0.7-0.89 strong, and 0.9-1.0 very strong.²⁴ Statistical significance was determined at $p < 0.05$.

RESULTS

Records of 196 patients were initially screened against the eligibility criteria with 114 eligible individuals sent a mailout to inform them of the study. Thirty-eight partic-

ipants responded with 24 ultimately participating in the study ($n = 24$; 42.6 ± 12.3 years; 17 male), having undergone either operative ($n = 12$; 39.0 ± 8.9 years; 9 male) or non-operative management ($n = 12$; 46.2 ± 14.1 years; 8 male). Patient demographics are shown in [Table 1](#).

HEEL-RISE TEST REPETITIONS

Heel-rise repetitions did not differ between limbs as measured with the LPT ($F_{(1,44)} = 1.848$, $p = 0.181$), motion capture ($F_{(1,44)} = 0.942$, $p = 0.337$), or app ($F_{(1,44)} = 0.942$, $p = 0.337$; [Table 2](#)). Total repetitions were greater in the operative group when measured with motion capture ($F_{(1,44)} = 4.486$, $p = 0.040$) or the app ($F_{(1,44)} = 4.486$, $p = 0.040$), but not the LPT ($F_{(1,44)} = 2.118$, $p = 0.153$; [Table 2](#)). No interaction of group and side was found, suggesting any affected limb deficits were comparable between treatments.

HEEL-RISE TEST HEIGHT

Peak heel-rise height (centimeters; cm) was reduced on the affected limb when measured on all devices (motion capture $F_{(1,44)} = 6.650$, $p = 0.013$; app $F_{(1,44)} = 6.374$, $p = 0.015$, LPT ($F_{(1,44)} = 4.699$, $p = 0.036$), with no effect of group or interaction of group and limb. There was no main effect of limb on accumulated heel-rise height (motion capture $F_{(1,44)} = 3.111$, $p = 0.085$, app $F_{(1,44)} = 2.936$, $p = 0.094$, LPT $F_{(1,44)} = 2.822$, $p = 0.100$). While not statistically significant, the mean difference in accumulated height between limbs was lower on the affected limb (motion capture -52.7 cm [95%CI -113.0 – 7.5 cm, $p = 0.085$], app -53.1 cm [95%CI -115.5 – 9.3 cm, $p = 0.094$], LPT -43.9 cm [95%CI -97.0 – 8.8 cm, $p = 0.100$]), with observed power of 0.407, 0.388 and 0.376 for motion capture, app and LPT respectively. Data are presented in [Table 2](#).

HEEL-RISE TEST WORK

While total work (Joules [J]) was reduced on the affected limb (mean difference of -403.5 J [95%CI -41.5 – 902.6], -434.7 J [95%CI -924.3 – 54.8 J], and -370.4 J [95%CI -802.6 – 61.9 J] on the motion capture, app, and LPT respectively),

Table 2. Single-Leg Heel-Rise Test Performance

	Operative		Non-operative		Statistics		
	Unaffected	Affected	Unaffected	Affected	Limb	Group	Interaction
Repetitions							
LPT	25.4 ± 9.7	21.4 ± 11.6	21.2 ± 4.8	18.1 ± 8.7	$F_{(1,44)} = 1.848$ $p = 0.181$	$F_{(1,44)} = 2.118$ $p = 0.153$	$F_{(1,44)} = 0.031$ $p = 0.861$
Motion capture	32.2 ± 17.7	28.7 ± 14.9	24.3 ± 7.5	20.5 ± 9.7	$F_{(1,44)} = 0.0942$ $p = 0.337$	$F_{(1,44)} = 4.486$ $p = \mathbf{0.040}$	$F_{(1,44)} = 0.002$ $p = 0.965$
App	32.2 ± 17.7	28.7 ± 14.9	24.3 ± 7.5	20.5 ± 9.7	$F_{(1,44)} = 0.0942$ $p = 0.337$	$F_{(1,44)} = 4.486$ $p = \mathbf{0.040}$	$F_{(1,44)} = 0.002$ $p = 0.965$
Peak Height (cm)							
LPT	10.08 ± 2.13	8.64 ± 2.13	8.98 ± 2.43	7.31 ± 2.55	$F_{(1,44)} = 4.699$ $p = \mathbf{0.036}$	$F_{(1,44)} = 2.99$ $p = 0.096$	$F_{(1,44)} = 0.025$ $p = 0.876$
Motion capture	8.99 ± 1.86	7.58 ± 2.24	9.44 ± 4.54	6.45 ± 2.41	$F_{(1,44)} = 6.650$ $p = \mathbf{0.013}$	$F_{(1,44)} = 0.154$ $p = 0.697$	$F_{(1,44)} = 0.0853$ $p = 0.361$
App	8.97 ± 1.88	7.59 ± 2.34	8.17 ± 1.96	6.46 ± 2.26	$F_{(1,44)} = 6.374$ $p = \mathbf{0.015}$	$F_{(1,44)} = 2.518$ $p = 0.120$	$F_{(1,44)} = 0.074$ $p = 0.786$
TOTAL HEIGHT (cm)							
LPT	201.5 ± 103.9	158.4 ± 119.1	158.4 ± 59.5	113.7 ± 65.3	$F_{(1,44)} = 2.822$ $p = 0.100$	$F_{(1,44)} = 2.823$ $p = 0.100$	$F_{(1,44)} = 0.001$ $p = 0.997$
Motion capture	232.3 ± 151.4	175.4 ± 119.1	163.1 ± 51.1	114.7 ± 56.4	$F_{(1,44)} = 3.111$ $p = 0.085$	$F_{(1,44)} = 4.721$ $p = \mathbf{0.035}$	$F_{(1,44)} = 0.020$ $p = 0.888$
App	240.9 ± 152.6	184.7 ± 127.7	167.8 ± 54.8	117.9 ± 58.6	$F_{(1,44)} = 2.936$ $p = 0.094$	$F_{(1,44)} = 5.115$ $p = \mathbf{0.029}$	$F_{(1,44)} = 0.010$ $p = 0.919$
Work (J)							
LPT	1703.3 ± 796.7	1339.0 ± 973.1	1428.9 ± 530.9	1052.5 ± 586.7	$F_{(1,44)} = 2.985$ $p = 0.091$	$F_{(1,44)} = 1.710$ $p = 0.198$	$F_{(1,44)} = 0.001$ $p = 0.978$
Motion capture	1941.2 ± 1144.2	1475.6 ± 937.2	1459.7 ± 430.0	1064.3 ± 510.7	$F_{(1,44)} = 3.378$ $p = 0.073$	$F_{(1,44)} = 3.633$ $p = 0.063$	$F_{(1,44)} = 0.022$ $p = 0.882$
App	2012.4 ± 1152.5	1550.4 ± 1002.8	1501.8 ± 463.8	1094.4 ± 532.3	$F_{(1,44)} = 3.203$ $p = 0.080$	$F_{(1,44)} = 3.959$ $p = 0.053$	$F_{(1,44)} = 0.013$ $p = 0.911$

Data are represented as mean ± standard deviation. cm= centimetres; J= joule; LPT= Linear Position Transducer. Bolded text indicates statistical significance.

the effect of limb (motion capture $F_{(1,44)} = 3.378$, $p = 0.073$; app $F_{(1,44)} = 3.203$, $p = 0.080$; LPT $F_{(1,44)} = 2.985$, $p = 0.091$), group (motion capture $F_{(1,44)} = 3.633$, $p = 0.063$; app $F_{(1,44)} = 3.959$, $p = 0.053$; LPT $F_{(1,44)} = 1.710$, $p = 0.198$) and interaction of limb and group (motion capture $F_{(1,44)} = 0.022$, $p = 0.882$; app $F_{(1,44)} = 0.013$, $p = 0.911$; LPT $F_{(1,44)} = 0.001$, $p = 0.978$), did not reach statistical significance. Similarly, the mean difference in work was reduced in the non-operative group when measured with motion capture (-446.4 J [95%CI -918.0 – 26.6 J; $p = 0.063$]) and app (-483.3 J [95%CI -927.9 – 6.2 J; $p = 0.053$]) with an observed power of 0.462 and 0.495 respectively. Data is represented in [Table 2](#).

DEVICE AGREEMENT AND INTRACLAS CORRELATION COEFFICIENTS

Strong, positive correlations were demonstrated between all devices, with the highest between motion capture and the app ($r^2 = 0.997$), followed by the LPT and app ($r^2 = 0.906$) and motion capture and LPT ($r^2 = 0.905$) ($p < 0.001$). Bland-Altman limits of agreement for total work and LSI in total work are shown in [Table 3](#) and [4](#), respectively.

DISCUSSION

This study compared the use of LPT, two-dimensional motion capture and the Calf Raise app to quantify repetition number, heel-rise height, and total work during the SLHR test in patients who were managed either operatively or non-operatively for ATR. The current results revealed a strong positive correlation between the motion capture software and Calf Raise app; however, Bland-Altman plots had wide limits of agreement for both total work and the LSI of total work across all methods. Significant differences were found between operative and non-operative groups in the number of heel-rise repetitions and total height while using motion capture and the Calf Raise app, while there were no significant differences for total work. Although potentially clinically relevant differences were observed between affected and unaffected sides for repetitions, height, and work, they were not statistically significant.

As the focus of this study was to compare different SLHR measurement methodologies, correlation and limit of agreement analyses were employed. Comparisons of total heel-rise work between LPT with motion capture (ICC 0.893), and LPT with the app (ICC 0.881) demonstrated

Table 3. Intraclass Correlation Coefficients and Bland Altman Limits of Agreement for total work during the SLHR

Comparison	ICC (95%CI)	Bland-Altman	
		Bias (SD)	95% Limits of Agreement
LPT ^a vs app ^b	0.881 (0.774 – 0.936)	158.9 (373.7)	-573.7 – 891.4
LPT ^a vs motion capture ^c	0.893 (0.814 – 0.939)	104.3 (360.7)	-602.6 – 811.2
Motion capture ^c vs app ^b	0.995 (0.976 – 0.998)	54.54 (70.27)	-83.19 – 197.30

LPT= Linear Position Transducer; SD= standard deviation; ^bMotion capture; ^cCalf Raise App**Table 4. Intraclass Correlation Coefficients and Bland Altman Limits of Agreement of the Limb Symmetry Index for total work during the SLHR.**

Comparison	ICC (95%CI)	Bland-Altman	
		Bias (SD)	95% Limits of Agreement
LPT ^a vs app ^b	0.789 (0.571 – 0.903)	1.51 (16.89)	-31.60 – 34.61
LPT ^a vs motion capture ^c	0.771 (0.539 – 0.894)	1.58 (17.70)	-33.12 – 36.27
Motion capture ^c vs app ^b	0.990 (0.978 – 0.996)	-0.067 (3.22)	-6.38 – 6.25

LPT= Linear Position Transducer; SD= standard deviation; ^bMotion capture; ^cCalf Raise App

a relatively strong positive correlation, whereas the correlation between motion capture and the app (ICC 0.995) showed a near perfect positive correlation. This is consistent with previous work that found good to excellent concurrent validity (ICC $\geq$ 0.878) between motion capture and the Calf Raise app, which also showed a strong relative agreement.¹⁸ Similarly, another study confirmed the apps validity and reliability compared to three-dimensional motion capture in rugby players following a familiarization session.¹⁹ This supports that there is a strong relationship between devices and their ability to determine total heel-rise work. However, correlation does not reflect the magnitude of difference between devices. Therefore, a Bland-Altman Limits of Agreement analysis between devices resulted in wide confidence intervals, indicating that values obtained from devices cannot be used interchangeably.

Significant differences in heel-rise repetitions were found between groups when comparing motion capture and Calf Raise app, whereas the LPT did not. This greater agreement is likely due to the use of the same video file. Additionally, the operative group was younger and had a longer follow-up period than the non-operative group, which may be a contributing factor to the higher performance. While there was no statistically significant difference in heel-rise repetitions between limbs, the current results are consistent with previous work, with a two or four heel-rise repetition difference.^{10,25} This study was not adequately powered to detect this between-group difference. Additionally, previous research has mainly focused on side-to-side comparisons using LSI rather than comparison of operative vs non-operative management.^{5,9-11,25} Studies evaluating the LSI of heel-rise repetitions have reported values of 82-95%.^{5,9,11,25} Collectively, these findings suggest that differences between heel-rise repetitions may exist between limbs. Nevertheless, heel-rise repetitions and LSI can be informa-

tive for future work to ensure adequate sampling for trials comparing functional performance after operative or non-operative management of ATR.

Peak heel-rise height was significantly reduced on the affected limb regardless of the type of equipment used for assessment. This is consistent with previous work reporting side-to-side differences in mean heel-rise height after ATR where multiple measurement methods were not utilized.^{7,25} This difference may be due to impaired plantar flexor strength, as this cohort previously demonstrated angle-specific torque deficits, Achilles tendon elongation and thickening, and gastrocnemius atrophy.²⁰ Additionally, total heel-rise height revealed differences that were not statistically significant, by recording the total number of heel-rises of each limb. The observed values suggest there may be clinically meaningful differences that are not reflected by repetitions alone.

Significant differences were found in total heel-rise height between groups, which could be due to the operative group being younger and having a later follow-up period. Again, a reduction in affected limb total heel-rise height compared to their unaffected limb was observed, but this did not reach a statistically significant difference. Interpretation across previous studies evaluating heel-rise height is challenging due to variability in outcome measurements; some studies quantify heel-rise height using LSI, while others report mean height per repetition. In five studies that examined heel-rise LSI, values ranged from 60-95% with only two studies demonstrating significant differences between limbs.^{11,25-28} Between group comparisons were not done in the majority of the above studies, with only one finding no difference between groups.²⁶ As such, this variability in measurement approaches limits direct comparisons which may reduce the clarity of meaningful differences in functional performance and recovery. The current

findings of differences between heel-rise height and heel-rise repetitions are consistent with previous work indicating that heel-rise repetitions are not an adequate measure of performance during rehabilitation,⁵ as they are unable to show differences that are notable by using height measurements.

While there were no significant differences observed in heel-rise work between limbs and groups, this may still have clinical relevance as heel-rise work is an indicator of functional performance following ATR^{5,16} and warrants discussion. Given previous findings of functional and morphological impairments following ATR from this cohort, including tendon elongation and reduced muscle volume,²¹ force production may be limited, leading to lower work output. Further investigation with a larger sample size is necessary to confirm if impairments in heel-rise work exist between limbs or treatment groups. Moreover, there is conflicting evidence on heel-rise work between limbs.^{9,25,29} One study reported persistent impairments in heel-rise work on the injured limb in patients who received operative treatment one year post-operatively,²⁵ while others report no differences between limbs within one⁹ to three years post-operative.²⁹ However, few studies have investigated heel-rise work in relation to operative or non-operative management, highlighting a need for further research, ideally with randomized treatment allocation and standardized follow-up intervals.

Moreover, variations in methodology may contribute to the discrepancies observed across studies. A systematic review examining the consistency and acceptance of the SLHR test's evaluation purposes, test parameters, and outcome measurements indicated that both test purpose and parameters varied across the literature, with limited reporting of reliability and validity.³⁰ Additionally, cadence and positioning are both critical factors that can significantly influence SLHR outcomes. Recent work has shown that the cadence used during the SLHR test can influence total vertical displacement, total work, peak height, and peak power.¹⁶ Between a cadence of 30, 60 and 120 bpm, 60 bpm resulted in greater vertical displacement and work while peak height and power were greater at 120 bpm. Additionally, a study comparing the SLHR test at 0°, 10°, and full ankle dorsiflexion found that the 0° resulted in greater repetitions, total vertical displacement and positive work, 10° was greatest peak vertical height, and full ankle dorsiflexion was lowest in all outcomes.³¹ Collectively, these findings highlight the importance of standardizing the SLHR test, as performance metrics can vary significantly. These variations in performance may reflect testing variability rather than true functional deficits or recovery

progress, which is crucial when assessing patients following ATR.

LIMITATIONS

A limitation of this study was that the Calf Raise app was developed for real-time acquisition, whereas the current analyses were conducted using recorded data from a common file. This approach does not fully reflect how the app would be used in clinical practice, which may impact the translation of these findings. Nevertheless, the ability to post-process the video files as done in this study would also be possible in the clinical setting. Immediate feedback could influence a patient's technique or effort, resulting in differing performance outcomes. Additionally, the sample was underpowered for between-group comparisons on operative and non-operative patients; however, this was not the primary focus of this paper.

CONCLUSION

Positive correlations were found between motion capture and Calf Raise app; however, Bland-Altman plots had wide limits of agreement for both total work and the LSI of total work across the three available technologies for SLHR quantification. There were significant differences between operative and non-operative groups in the number of heel-rise repetitions (regardless of limb) and total height while using motion capture and the Calf Raise app, and no significant differences for total work. These findings indicate that LPT, motion capture, and Calf Raise app can be used to quantify repetitions, work, and heel-rise height in patients following ATR. However, due to wide limits of agreement between devices, values should not be used interchangeably.

CONFLICTS OF INTEREST

The authors have no conflicts of interest to report.

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