Foam Rolling Prescription: A Clinical Commentary

David G. Behm,[1] Shahab Alizadeh,[1] Saman Hadjizadeh Anvar,[1,2] Mohamed Mamdouh Ibrahim Mahmoud,[1] Emma Ramsay,[1] Courtney Hanlon,[1] and Scott Cheatham[3]

[1]School of Human Kinetics and Recreation, Memorial University of Newfoundland, St. John's, Newfoundland and Labrador, Canada; [2]Faculty of Physical Education and Sports Science, University of Tehran, Tehran, Iran; and [3]Division of Kinesiology, California State University Dominguez Hills, Carson, California

Abstract

Behm, DG, Alizadeh, S, Hadjizadeh Anvar, S, Mahmoud, MMI, Ramsay, E, Hanlon, C, and Cheatham, S. Foam rolling prescription: a clinical commentary. *J Strength Cond Res* 34(11): 3301–3308, 2020—Although the foam rolling and roller massage literature generally reports acute increases in range of motion (ROM) with either trivial or small performance improvements, there is little information regarding appropriate rolling prescription. The objective of this literature review was to appraise the evidence and provide the best prescriptive recommendations for rolling to improve ROM and performance. The recommendations represent studies with the greatest magnitude effect size increases in ROM and performance. A systematic search of the rolling-related literature found in PubMed, ScienceDirect, Web of Science, and Google Scholar was conducted using related terms such as foam rolling, roller massage, ROM, flexibility, performance, and others. From the measures within articles that monitored ROM (25), strength (41), jump (41), fatigue (67), and sprint (62) variables; regression correlations and predictive quadratic equations were formulated for number of rolling sets, repetition frequency, set duration, and rolling intensity. The analysis revealed the following conclusions. To achieve the greatest ROM, the regression equations predicted rolling prescriptions involving 1–3 sets of 2–4-second repetition duration (time for a single roll in one direction over the length of a body part) with a total rolling duration of 30–120-second per set. Based on the fewer performance measures, there were generally trivial to small magnitude decreases in strength and jump measures. In addition, there was insufficient evidence to generalize on the effects of rolling on fatigue and sprint measures. In summary, relatively small volumes of rolling can improve ROM with generally trivial to small effects on strength and jump performance.

Key Words: roller massage, self-myofascial release, flexibility, strength, power

Introduction

Research investigating foam rollers, roller massagers, and other similar devices have generally reported increased range of motion (ROM), diminished perceived pain, accelerated recovery from exercise-induced muscle damage and augmented performance (5,17,48,62,67). Rolling can acutely increase ROM (6–13) by 3–23% (30,63) persisting for 20 minutes (37,41,52). Wilke et al.'s (68) meta-analysis examined 26 high methodological quality rolling trials reporting a large magnitude positive effect of rolling on ROM, contrasting with Wiewelhove et al. (67), who reported only a small (4%) ROM increase. Hughes and Ramer's (35) recent review of 22 articles concluded that although many rolling studies report an acute positive effect on ROM, the long-term effectiveness is still inconclusive.

The rolling protocols used throughout the literature are quite diverse with no definitive agreement regarding the most efficacious volume (number of sets), duration, rolling frequency, or intensity. Minimal durations of 5–10 seconds of rolling (64) have shown improved joint ROM, but many investigations have used multiple sets of 30–60 seconds of rolling. Generally, longer rolling durations seem to provide greater ROM. For example, 10 seconds rolling provided greater ROM than 5 seconds (64). Furthermore, 60 seconds of rolling tends to provide more enhanced ROM (7–11) than shorter durations, but specific rolling durations have not been directly compared. Wilke et al. (68) performed a moderator analysis in their meta-analysis and stated that the choice of foam rolling speed and duration can be left to the choice of the client. Alternatively, Hughes and Ramer (35) and Hendricks et al. (33) proposed that the optimum rolling dosage for ROM is 90 and 90–120 seconds respectively. However, there were no specific recommendations regarding how this volume should be achieved in number of sets, rolling speed, or frequency or rolling intensity. It is crucial that a critical and comprehensive examination of the literature is needed to provide specific recommendations regarding optimal rolling protocols for increasing ROM.

Unlike the stretching literature, which has reported impaired performance following prolonged static stretching (10,11,40), the rolling literature generally reports no significant deficits in subsequent muscle strength (3,6,29,32,45,46,49,64), jump height (4,6,34,36), sprint time (50), or fatigue endurance (14). On the contrary, other rolling studies, demonstrate improved strength (31,58), power (58), sprint speed (58), neuromuscular efficiency during a lunge (15), and knee joint proprioception (23). Although the Hughes and Ramer review (35) indicates that rolling does not provide significant performance improvements, a meta-analysis by Wiewelhove et al. (67) reported generally small-to-negligible positive foam rolling effects on performance and recovery, albeit with some exceptions such as improved sprint performance, flexibility, or muscle pain reduction. However, not all rolling

Address correspondence to Dr. David G. Behm, dbehm@mun.ca.

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studies demonstrate performance enhancement. Monteiro et al. (54) applied 60, 90, and 120 seconds of rolling between 4 sets of resisted knee extensions (10 repetition maximum load). The researchers found that all rolling durations reduced the number of knee extension repetitions (120 seconds rolling: 14%↓, 60 and 90 seconds: 8–9↓%). In summary, although the literature generally indicates that rolling either does not impair performance or can provide small magnitude performance improvements, the specific rolling prescription for optimal subsequent performance is also not yet elucidated.

The objective of this clinical commentary review was to appraise the rolling (foam rollers and roller massagers) literature to evaluate and recommend the exercise prescriptions that would provide large magnitude effect size improvements (i.e., volume [number of sets], repetition duration, rolling velocity/frequency, and intensity) for ROM and performance.

Methods

Experimental Approach to Problem

Search Strategy. Between September and November 2019, 6 of the investigators performed a systematic search of the rolling-related literature following PRISMA-P review guidelines (Figure 1). Articles relevant to the research question were identified using MEDLINE (PubMed), ScienceDirect, Web of Science, and Google Scholar. The terms for all databases were similar, but modified according to the requirements of the respective search engines. Terms used for the search were ("foam rolling" OR "foam rollers" OR "roller massage" OR "roller massager" OR "self-myofascial release" or "massage rollers") AND ("range of motion" OR "flexibility" OR "performance" OR "force" OR "power" OR "strength" OR "endurance" OR "fatigue" OR "jump" OR "sprint" OR "run"). In addition, the reference lists of all included studies and the primary investigator's personal computer library were checked to identify further potentially eligible papers.

Inclusion Criteria. Full text (no abstracts) randomized experimental trials were considered for inclusion. Further inclusion criteria were (a) healthy adults, (b) performance of foam rolling or roller massage (no manual massage), (c) testing of acute effects on ROM or selected performance measures (i.e., isometric and isokinetic force, jump height or power, sprint speed, and fatigue endurance), and (d) publication in English in a peer-reviewed journal. If a trial examined both acute (within an experimental session, measures were taken immediately or within 10 minutes after the intervention) and chronic (prolonged training) effects, only the immediate (acute) effects data were included. Exclusion criteria included studies investigating only chronic (i.e., training) effects, rolling in combination with other treatments, or pathological populations. Abstracts were excluded because they would not be fully peer-reviewed, whereas reviews were excluded because they were not the primary source for data values.

Data Extraction. Using a standardized assessment sheet, the 6 investigators independently extracted the outcomes (pre-post values and *SD*s) from the sample size, sex, age, trained state, interventions (foam rollers or roller massagers), and rolling prescription variables (number of sets, repetition duration, inter-repetition recovery time, rolling speed or frequency, rolling intensity, and muscles rolled). The primary variables were the prescription variables. If a study provided more than one dependent variable (i.e., multiple strength or ROM tests), then all data were extracted. Based on the pre- and post-test means and *SD*, percentage changes and Cohen's *d* (20) effect sizes (ES) were calculated.

Procedures

Data Synthesis and Statistics. From all collected studies, the mean pre-to post-test changes plus *SD* were retrieved. If reporting was incomplete (i.e., missing SDs of the changes from baseline), the required information was requested from the corresponding authors of the trials. If no absolute numerical values (i.e., tables, text, or correspondence with means and *SD*) could be obtained, missing data were determined visually from figures or calculated from *t* values/*SE* if possible.

To quantitatively analyze rolling intensities, the intensity descriptions were assigned a percentage number where possible. For example, a description of rolling at the maximum possible discomfort was assigned 100%. If ratings of perceived exertion were used then the number on a scale of 10 was multiplied by 10 to provide a percentage (i.e., 7/10 = 70%). In cases where body mass, specific resistance (i.e., 13 kg), or relative resistance (i.e., 25% of body mass) were used, a valid and reliable quantitative number could not be assigned, and these measures were not included in the rolling intensity analysis.

The ES and prescription parameter values were subjected to linear, logarithmic, and quadratic regression analyses to develop predictive equations to determine the prescription parameters (i.e., number of sets, repetition duration, rolling intensity or rolling frequency) that provided large magnitude effect size increases. Because all parameters were best described by quadratic equations ($y = ax^2 + bx + c$), only quadratic equations and predictions are presented. When the regression correlation was not significant, a one-way analysis of variance (ANOVA) was conducted to determine whether significant differences existed between the variables. Tukey post-hoc analyses were used if significant differences were detected. Meta-analyses were not conducted as the author just published a multi-level meta-analysis on rolling-induced ROM changes (68) this year and the volume and heterogeneity of the performance data were insufficient for a meta-analysis.

Results

Search Results

A total of 73 articles and 254 measures were used in the analysis. A flow diagram of the literature search is displayed in Figure 1. Supplementary tables 1–5 detail the findings of the studies and specific measures used for the analysis of ROM (see Supplementary Table 1: 58 studies, Supplemental Digital Content 1, http://links.lww.com/JSCR/A206), strength/force (see Supplementary Table 2: 13 studies, Supplemental Digital Content 2, http://links.lww.com/JSCR/A207), jump (see Supplementary Table 3: 17 studies, Supplemental Digital Content 3, http://links.lww.com/JSCR/A208), fatigue endurance (see Supplementary Table 4: 5 studies, Supplemental Digital Content 4, http://links.lww.com/JSCR/A209), and sprint (see Supplementary Table 5: 2 studies, Supplemental

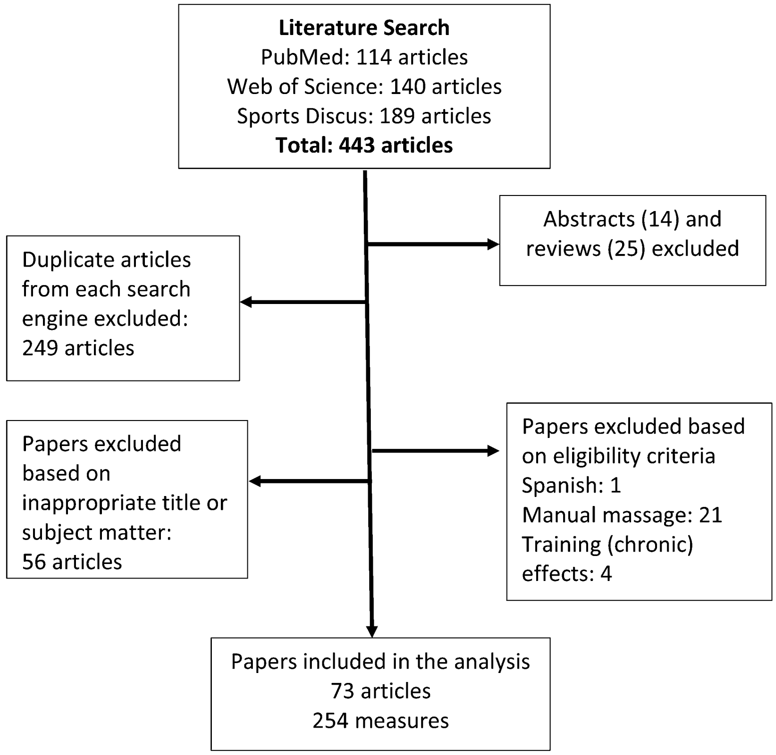

Figure 1. Flow chart illustrating different phases of the search and study selection using the following nomenclature: ([“Foam rolling” OR “foam rollers” OR “roller massage” OR “roller massager” OR “self-myofascial release” or “massage rollers”] AND [“range of motion” OR “flexibility” OR “performance” OR “force” OR “power” OR “strength” OR “endurance” OR “fatigue” OR “jump” OR “sprint” OR “run”]).

Digital Content 4, http://links.lww.com/JSCR/A209) measures respectively. A number of studies included multiple measures (i.e., ROM and strength or ROM and jump), hence the sum of the number of studies from Supplemental Digital Content 1–5, Tables 1–5, http://links.lww.com/JSCR/A206, http://links.lww.com/JSCR/A207, http://links.lww.com/JSCR/A208, and http://links.lww.com/JSCR/A209 exceeds the reported total number of studies (73 studies). Second, not all studies included all reported variables (i.e., rolling frequency, intensity, set duration, or others) and thus a variety of numbers of measures are reported for each section.

Range of Motion

Effect of Number of Sets on Range of Motion. Based on 153 measures (131 positive and 22 negative ES), the quadratic regression coefficient ($r = 0.326$; $p = 0.02$) and corresponding equation ($y = 0.154x^2 - 0.729x + 0.266$) (Figure 2) predicted large magnitude ES with 1 ($d = 0.84$), 2 ($d = 1.1$) and 3 ($d = 1.06$) rolling sets, moderate ES with 4 ($d = 0.71$) diminishing to trivial magnitudes of change with 5 ($d = 0.056$) or greater number of repetitions.

Effect of Rolling Set Duration on Range of Motion. Based on 128 measures that reported set duration (111 positive and 17 negative ES), the quadratic regression coefficient ($r = 0.241$; $p < 0.024$) and corresponding equation ($y = -0.00002619x^2 + 0.006x + 0.855$) (Figure 3) predicted large magnitude ES with 30-second ($d = 1.01$), 60-second ($d = 1.12$), 90-second ($d = 1.18$), and 120-second ($d = 1.19$) rolling set durations with a small effect size with 300-second ($d = 0.29$) set duration.

Effect of Rolling Frequency (Speed) on Range of Motion. Based on 69 measures that reported rolling speed or frequency, (56 positive and 13 negative ES), the quadratic regression coefficient ($r = 0.404$; $p = 0.026$) and corresponding equation ($y = -0.526x^2 + 2.823x - 1.88$) (Figure 4) predicted large magnitude ES for increased ROM with 2-second ($d = 1.66$), 3-second ($d = 1.85$), and 4-second ($d = 1.00$) rolls (duration of a single roll in one direction over the length of a body part), with small (0.417) magnitude ROM improvements with 1-second rolling frequency respectively.

Effect of Rolling Intensity on Range of Motion. Based on 99 measures (88 positive and 11 negative ES) that specified rolling intensity, there were no significant regression coefficients for rolling intensity and ROM (quadratic: $r = 0.159$; $p = 0.22$). The one way ANOVA indicated there was no significant difference between rolling intensities.

Strength and Jump Measures

Effect of Number of Sets on Strength and Jump Measures. There were no significant quadratic regression coefficients for number of sets and ES for strength ($r = 0.105$; $p = 0.84$) or jump ($r = 0.131$; $p = 0.82$) performance. With 36 total (11 positive and 25 negative) findings for strength measures and 32 total (16 positive and 16 negative) findings for jump measures, there were no significant difference between sets of rolling for strength or jump performance. The mean overall effect size for strength and jump measures were a trivial magnitude -0.19 ± 0.36 and -0.13 ± 0.43 respectively.

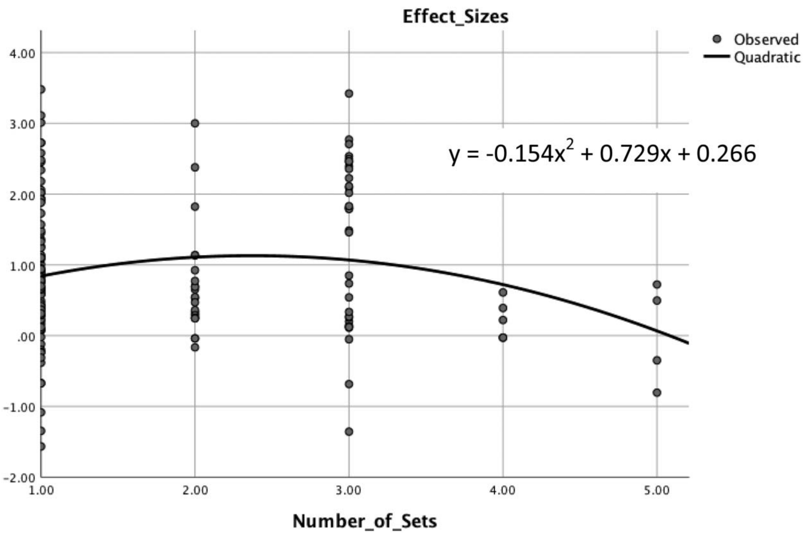

Figure 2. Quadratic equation (r = 0.326; p = 0.02) derived from number of sets to achieve large effect size magnitude for range of motion (ROM). Effect sizes on y axis. Sets on x-axis.

Effect of Rolling Set Duration on Strength and Jump Measures. Of the 32 strength measures that specified set duration, 9 had positive and 23 had negative ES, whereas with jump measures there were 14 positive and 23 negative ES. There were no significant ($r = 0.32$, $p = 0.21$) regression coefficients for set duration and ESs for strength performance. Overall, the mean strength ES was a small magnitude -0.22 ± 0.35. There was no significant difference between rolling set durations for strength performance. All rolling durations (5, 10, 20, 30, 60-second) exhibited negative trivial to small magnitude ES.

Of the 37 jump measures that specified set duration, 24 used 30-second rolls, 10 used 60-second rolls, and one each used 20, 180, and 300-second rolling durations respectively and thus without a normal distribution, a predictive equation could not be calculated. There was no significant ($p = 0.8$) difference between the trivial magnitude ES with 30-second ($d = -0.15 \pm 0.09$) and 60-second ($d = -0.17 \pm 0.11$) rolling durations. A study by Drinkwater et al. (24) used a rolling duration of 3 minutes with a small magnitude effect size impairment of -0.35.

Effect of Rolling Frequency on Strength and Jump Measures. Of the 32 strength measures that detailed rolling frequency, 9 had positive and 23 had negative ES, whereas with the 20 jump measures that reported rolling frequency, 3 had positive and 17 had negative ES. There were no significant strength ($r = 0.37$, $p = 0.11$) or jump ($r = 0.22$, $p = 0.7$) regression coefficients for rolling frequency (duration from proximal to distal segment of limb). Four strength measures used a 0.5 second rolling frequency while other study measures used 1-second (62), 2-second (31), 3-second (62), 4-second (48), 10-second (31), 15-second (67), and 60-second (62) rolling frequencies. There were no significant effect size differences between rolling frequencies for strength and jump measures. All strength measure rolling frequencies showed trivial to small magnitude effects except for 10-second rolling duration, which displayed a moderate

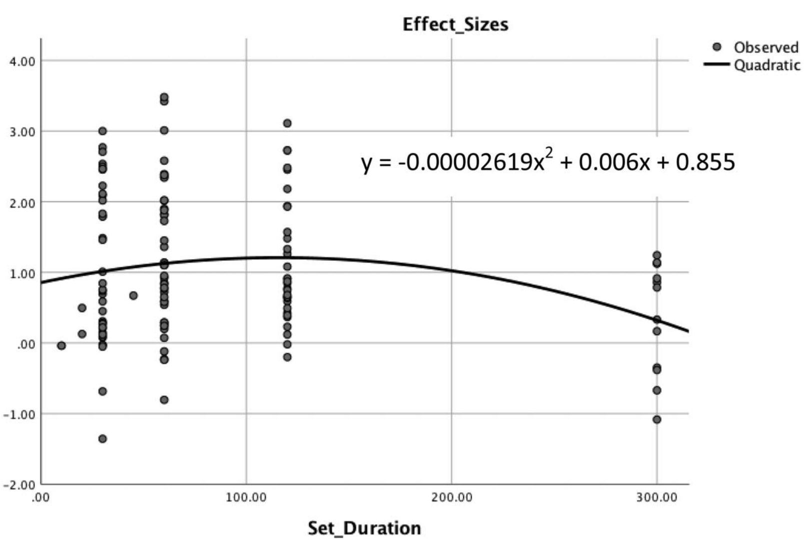

Figure 3. Quadratic equation (r = 0.241; p = 0.024) derived from the set duration to achieve large effect size magnitude for range of motion (ROM). Effect sizes on y axis. Repetitions on x-axis.

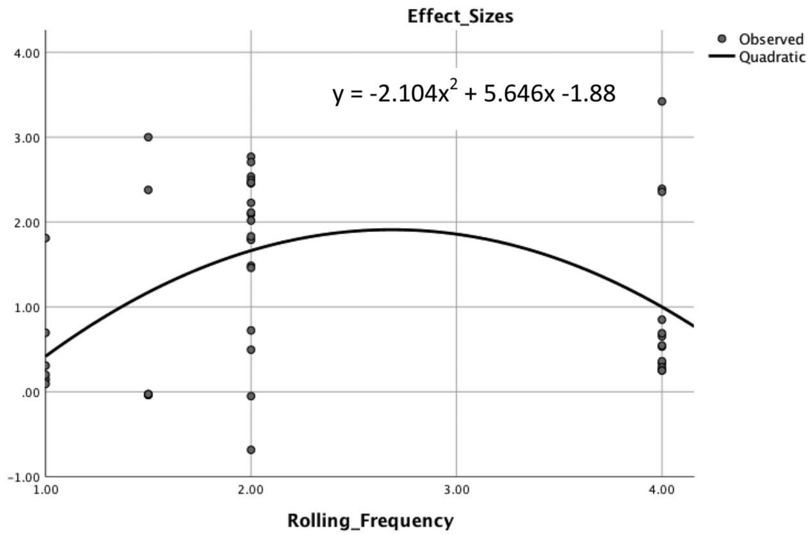

Figure 4. Quadratic equation ($r = 0.404$; $p = 0.026$) derived from the rolling frequency (time to roll the entire length of a limb in one direction) to achieve large effect size magnitude for range of motion (ROM). Effect sizes on y axis. Frequency on x-axis.

positive magnitude effect (although not significantly different from other frequencies). Nine jump measures used a 1-second rolling frequency, whereas 5 measures used 2-second, one measure used 3-second, 3 measures used 4-second, and 2 measures used 6-second rolls, with all trivial magnitude ES.

Effect of Rolling Intensity of Strength and Jump Measures. Of the 32 strength measures, 9 had positive ES and 23 negative ES, compared with the 16 jump measures, which demonstrated 3 positive and 13 negative ES. Sixteen of the 32 strength measures involved body mass on a foam roller, with 2 measures using 25% of body mass and 4 measures using 13 kg. Nine of the measures reported rolling intensities of 50% (62), 60% (48), 70% (5), 90% (62), and 100% (48). Thus, there were too few reported intensities to perform a regression analysis.

With jump measures, only 2 intensities were reported with 70% (2 measures) and 100% (14 measures) of maximum discomfort or pressure displaying nonsignificantly different ($p = 0.3$) mean small and trivial magnitude ES of -0.37 ± 0.75 and -0.06 ± 0.24 respectively. There were no significant ($p = 0.8$) regression coefficients relating rolling intensity and ES for jump height performance.

Fatigue Endurance and Sprint

There were only 5 studies (15 measures) that examined changes in fatigue endurance after rolling with 11 negative, 2 positive ES and 2 measures with no available ES. The mean responses elicited an effect size -0.89 ± 1.2.

There were only 2 studies that investigated sprint changes with rolling (Supplementary Table 5) with reported improvements of 1.2% (d: 0.85) and 6.2% (d: 0.24). There were insufficient number of studies to calculate regression equations.

Discussion

The most important findings in this review were that to achieve the greatest ROM, the rolling prescription should involve 1–3 sets of 2–4-second repetition duration (time for a single roll in one direction over the length of a body part) with a total rolling duration of 30–120-second per set. Second, there were no significant findings for strength and jump measures with generally trivial-to-small magnitude rolling-induced performance deficits.

In addition to the present findings of large magnitude improvements in ROM with 1–3 rolling repetitions, prior reviews (3,13,38,62) investigating the effects of rolling on ROM report that rolling provides acute increases in ROM, that can be maintained as long as 20 minutes (37,41,52). Hughes and Ramer's review (35) summarized that although many rolling studies report acute increases in ROM, the long-term effectiveness is still inconclusive. According to a recent meta-analysis by Wilke et al. (68) that reviewed 26 studies with high methodological quality, foam rolling had a large positive effect on ROM (SMD: 0.74, 95% CI 0.42–1.01, $p = 0.0002$). On the other hand, another meta-analysis by Wiewelhove et al. (67) reported only a small, mean 4% (Hedges $g = 0.34$) ROM increase. With 1–3 rolling repetitions, the present review of 58 studies (153 measures) found a mean large magnitude, Cohen's d effect size ROM increase of 1.0. Hence, the present study results indicate that substantial ROM increases can be achieved with a volume of 1–3 sets (2–4-second duration for each roll) with a total rolling duration of 30–120 seconds per set. These findings are generally in accord, but more expansive than the prescriptive reviews by Hughes and Ramer (35) and Hendricks et al. (33) who suggested the optimum dosage for rolling-induced increases in ROM is 90 or 90–120 seconds respectively. However, Hughes and Ramer and Hendricks prescriptions did not specify the particular number of sets, rolling duration, intensity, or other characteristics.

It is difficult to postulate whether these findings can be altered by the training background. Trained individuals are more likely to be more familiar with foam rolling devices. In the Wilke et al. (68) meta-analysis, only 3 of 25 studies recruited trained individuals. In alignment with Wilke's overall findings (primarily recreationally active subjects), the ROM of the trained individuals in the 3 studies increased significantly and substantially while in accord with the Wiewelhove (67) review the effects of foam rolling on performance and recovery of trained subjects were generally small to negligible.

The mechanisms underpinning these significant ROM increases with rolling may be quite diverse. Muscle, fascia, and skin are densely innervated by sensory neurons (60,61). A variety of receptors respond slowly (Merkel: small receptor field and Ruffini: large receptor field) or rapidly (Meissner small receptor field and Pacinian: large receptor field) to pressure and force. Although their primary responsibilities are for proprioception, Ruffini and Pacinian receptors contribute to sympathetic activity inhibition (contribute to muscle relaxation) (69). Ruffini receptors are more sensitive to tangential forces and lateral stretch (42), which would be characteristics associated with rolling. In addition, interstitial type III and IV are multi-modal receptors (i.e., pain and mechanoreceptors) that can affect sympathetic and parasympathetic activation decreasing heart rate, blood pressure, ventilation, and promoting vasodilation (46). Thus, they can also contribute to a more relaxed muscle with less resistance to movement.

Reduced muscle reflex activity can also contribute to a more relaxed muscle. Manual massage (12,28,55,56,65,68) and roller massage (70) have attenuated the Hoffman (H)-reflex by 40–90%. A decreased H-reflex may be attributed to decreased afferent excitability of the alpha motoneuron or increased presynaptic inhibition (1,39), inhibiting the reflex-induced activation of the rolled muscle.

Furthermore, a similar mechanism for stretch-induced increases in ROM as proposed by Magnusson (47) may be a rolling-induced increase in stretch tolerance. The experience of pain or discomfort with either stretching or rolling can be diminished with prolonged exposure allowing the individual to move beyond the prior limit of discomfort to achieve a greater ROM. Pain perception associated with delayed onset muscle soreness (44,59), myofascial tender spots (2), and evoked stimulation (16) have all been reduced with rolling. Pablos and colleagues (57) reported an increase in anti-inflammatory proteins and a reduction of pro-inflammatory proteins, when foam rolling after muscle damage in mice, which resulted in improved muscle recovery and performance. Massage can also stimulate parasympathetic activation; with changes in serotonin, cortisol, endorphin, and oxytocin contributing to a decreased pain perception (66) contributing to an increased ROM tolerance.

Thixotropic effects could also contribute to rolling-induced increases in ROM. The direct and undulating pressures of rolling can decrease the tissue fluid viscosity (43) providing less resistance to movement (9).

In summary, an array of mechanisms (i.e., increased stretch tolerance, decreased viscosity, fascial reflexes reducing sympathetic activation, attenuated muscle (H-) reflexes) may contribute to the acute rolling-induced increase in ROM. Based on the literature ROM can increase within 5–10-second of rolling (64), but substantial increases in ROM can be achieved with 1–6 minutes of rolling (1–3 sets of 2–4-second rolling repetition duration with 30–120-second per set).

There were no significant regression correlations between strength and jump performance ES with number of sets, set duration, or rolling frequency and insufficient data regarding rolling intensity. Overall, fatigue-induced changes in strength and jump performance yielded primarily trivial (strength: $d = -0.19 \pm 0.36$, jump: $d = -0.13 \pm 0.43$), but also small magnitude deficits in some studies. These findings of small-to-negligible effects are in accord with a meta-analysis by Wiewelhove (67), except they found generally positive foam rolling effects on performance and recovery, whereas the present review reports trivial-to-small negative effects. The possibility of small magnitude impairments may be related to some of the mechanisms that contribute to an increased ROM. As mentioned, rolling-induced activation of fascial reflexes can diminish sympathetic activation. A reduced sympathetic activation may hinder overall neural excitation decreasing the ability to fully activate the necessary muscles for the task. Moreover, a rolling-induced attenuation of H-reflexes (70) represents a decreased afferent excitability of the spinal motoneurons (25,71). The ability to fully activate muscles is contingent on the balance of excitation and inhibition of supraspinal, spinal, and afferent influences (7,8) and thus rolling-induced decreases in sympathetic and afferent excitation of motoneurons can negatively affect force and power production. However, it must be emphasized that the effects of rolling on strength and jump performance generated more trivial than small magnitude deficits.

Similarly, there were a dearth of rolling studies (5 studies) examining fatigue. Monteiro and colleagues (54) reported that passive rest provided 13.8, 8.6, and 9.1% greater knee extension repetitions than 120, 90, and 60 seconds of foam rolling. In a second study by Monteiro et al. (53) subjects performed 3 sets of 10 repetitions maximum knee extensions and found that the control group had 6.5 and 9.3% lower fatigue index (less force loss compared to pre-test) than foam rolling for 60 and 120 seconds of foam rolling respectively. In contrast, Fleckenstein et al. (26) reported that foam rolling either before (preventive) or after (regenerative) a fatigue protocol decreased the subsequent maximum voluntary contraction by 16 and 12% respectively. Although, 11 negative and 2 positive effect size measures may not constitute a comprehensive rolling review, the results tend to indicate the possibility of large magnitude impairments ($d = -0.89$) in fatigue endurance after rolling. Similar to the rationale underlying possible rolling-induced strength impairments, reduced sympathetic activation (51) and attenuation of H-reflexes (70) may contribute to a decrement in fatigue endurance.

There were only 2 studies examining the effects of foam rolling on sprint performance with 2 related measures. Both studies had their subjects foam roll using their body mass as the selected resistance. The D'Amico and Paolone (22) study used 6 repetitions of 30-second duration at a frequency of 5 seconds per body part and found an improvement in 800-m run time corresponding to a large magnitude effect size of 0.85. In contrast, the Giovanelli et al. (27) study used 1 repetition of 60 seconds with a 2-second per body part (0.5 Hz) rolling frequency resulting in a small positive magnitude effect size of 0.24 for the cost of running ($Joules \cdot kg^{-1} \cdot min^{-1}$). Although both studies reported positive effects on sprinting, such a small sample does not provide definitive conclusions.

Because rolling intensity was not consistently reported, there was insufficient data to provide an analysis of an appropriate rolling intensity for strength and jump performance. Furthermore, the lack of significant regression coefficients with rolling intensity and ROM suggests that a specific rolling pressure or intensity does not play a significant role in augmenting ROM. This finding is in accord with Grabow et al. (29) who reported that the rolling intensity (pressure) did not differentially affect ROM. In their study, rolling at 50, 70 or 90% of the maximum point of discomfort, induced similar increases in ROM.

If an individual wishes to maintain similar rolling pressures between sessions then according to Cheatham et al. (19), moderate and hard density rollers would be preferable. They reported that the reliability of the numeric pain rating scale had poor-to-moderate reliability with a soft roller (ICC = 0.60) contrasting with good reliability for moderate (ICC = 0.82) and hard density

(ICC = 0.90) rollers. Curran et al. (21) compared a multi-level rigid roller and a biofoam roller finding that the rigid roller provided more pressure. They speculated (without conducting a direct investigation) that the increased pressure might be more effective for releasing and treating myofascial adhesions in deeper soft tissue. However, Behm and Wilke (13) in their review suggested that there was insufficient evidence to state that the primary mechanisms underlying rolling are the release of myofascial restrictions. Hence, they postulated that the common term "self-myofascial release" devices was misleading. Another study by Cheatham et al. (18) compared the effects of different roller textures on ROM and pain pressure threshold (PPT). They reported that GRID (multiple rectilinear textured surfaces separated by shallow channels) and multi-level surface rollers induced significantly greater PPT and knee ROM (5–6^0) increases compared with a smooth textured roller (ROM increase: 3^0). They suggested that the architecture of the GRID and multi-level rollers may have induced greater tissue deformation leading to local mechanical and global neurophysiological effects. In summary, the limited literature on rolling intensity and roller surface characteristics suggest that higher rolling pressures do not provide significantly greater benefits, whereas there is some evidence that multi-level or grid type rollers may provide greater advantages than smooth rollers for ROM and PPTs.

There were a number of limitations to reviewing the rolling literature. Some restraints on this review would include that the studies were limited to the immediate (within 10 minutes of rolling) response of primarily healthy, young (only 3 studies used subjects with a mean age over 35 years) subjects and thus the recommendations may not directly apply to rehabilitation, elderly or pediatric populations or to more prolonged acute effects. Furthermore, training studies were not included, and thus chronic effects were not considered. In addition, there are a diverse array of devices (i.e., balls, vibrators, vibrating rollers, and others) and manual massage used to apply rolling pressure to the myofascia, but this review was restricted to foam rollers and roller massagers. The review only included English language randomized control trials. Effect sizes were used to compare the magnitude of responses to rolling, but it should be noted that there was a wide variety of measures used for ROM (i.e., different joints and protocols), strength (i.e., isometric, isokinetic, isoinertial), jump (stretch-shortening [i.e., countermovement and drop jumps] and non-stretch-shortening [i.e., squat jumps] type jumps), fatigue endurance (i.e., force fatigue index, visual analogue scale), and sprint (time vs. energy output) measures, which could affect the validity of the within-measure comparisons.

Furthermore, ROM increases were expressed as percentage values, whereas ROM is a dichotomous variable with a "ceiling" (e.g., full extension and flexion of the joint cannot exceed a certain value). Although expressing percentage ROM changes is not universally recommended, it was necessary to normalize the diverse ROM ranges among different joints.

In conclusion, an analysis of the available literature suggests that a rolling prescription that provides large magnitude immediate ROM increases should involve 1–3 sets of 2–4-second repetition duration with a total rolling duration of 30–120 seconds per set. The generally trivial to small magnitude effects on strength and jump measures indicate that rolling does not induce considerable performance deficits. Finally, there is insufficient evidence to definitively postulate on the effects of rolling on fatigue and sprint measures. Further research should endeavor to investigate the effects of a greater variety of rolling prescription variables (i.e., number of sets, set duration, rolling frequency and intensity) on strength, power, fatigue, sprint, and other performance characteristics.

Practical Applications

Rolling prescription for large magnitude immediate ROM increases should involve 1–3 sets of 2–4-second repetition duration with a total rolling duration of 30–120-second per set. Rolling does not induce meaningful (trivial) strength and jump performance deficits. Thus athletes, health, and fitness enthusiasts can use a relatively wide selection of repetitions, and durations to improve the extensibility of their muscles and tendons without significant concerns of performance impairments.

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