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Psychophysiological Effects of Massage-Myofascial Release After Exercise: A Randomized Sham-Control Study

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Abstract

Objective: The aim of this study was to evaluate the effect of massage on neuromuscular recruitment, mood state, and mechanical nociceptive threshold (MNT) after high-intensity exercise.
Design: This was a prospective randomized clinical trial using between-groups design.
Setting: The study was conducted at a university-based sports medicine clinic.
Participants: Sixty-two (62) healthy active students age 18–26 participated.
Interventions: Participants, randomized into two groups, performed three 30-second Wingate tests and immediately received whole-body massage-myofascial induction or placebo (sham ultrasound/magnetotherapy) treatment. The duration (40 minutes), position, and therapist were the same for both treatments.
Main outcome measures: Dependent variables were surface electromyography (sEMG) of quadriceps, profile of mood states (POMS) and mechanical nociceptive threshold (MNT) of trapezius and masseter muscles. These data were assessed at baseline and after exercise and recovery periods.
Results: Generalized estimating equations models were performed on dependent variables to assess differences between groups. Significant differences were found in effects of treatment on sEMG of Vastus Medialis (VM) ($p = 0.02$) and vigor subscale ($p = 0.04$). After the recovery period, there was a significant decrease in electromyographic (EMG) activity of VM ($p = 0.02$) in the myofascial-release group versus a nonsignificant increase in the placebo group ($p = 0.32$), and a decrease in vigor ($p < 0.01$) in the massage group versus no change in the placebo group ($p = 0.86$).
Conclusions: Massage reduces EMG amplitude and vigor when applied as a passive recovery technique after a high-intensity exercise protocol. Massage may induce a transient loss of muscle strength or a change in the muscle fiber tension–length relationship, influenced by alterations of muscle function and a psychological state of relaxation.

Introduction

Massage therapy is widely requested by sportspeople and trainers, but research findings on the benefits of its routine use have been controversial.[1,2] Better control over study conditions is required to elucidate the effects of this activity in the sports setting and allow definitive conclusions to be drawn.[3]

Massage is commonly applied to sportspeople during periods of fatigue in training. Fatigue is associated with muscle fiber changes that reflect the increased effort required to maintain a given level of mechanical performance.[4] These myoelectric alterations are observed as reductions in the amplitude of motor unit action potential[5] and motor unit recruitment threshold.[6,7] An increased electromyographic (EMG) amplitude[8] and alteration of temporal muscle sequencing[9] have been reported by authors using an eccentric exercise-induced delayed-onset muscle soreness (DOMS) model. However, supramaximal exercise (Wingate 30-s test) was found to produce a decrease in mean power frequency spectrum but no change in EMG amplitude.[10,11] These EMG changes are related to the accumulation of metabolites in the periphery and an ineffective afferent command to the central nervous system to implement neural recruitment strategies.

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The relaxation produced by massage therapy has proved capable of reducing local fatigue rate[3] and muscular excitability[12–14] by inducing relaxation. However, the effectiveness of this therapy at the myoelectric level has not yet been established,[2,15] and no evidence has been published on the EMG effects of myofascial release massage. Changes in neural recruitment after myofascial release can be studied by EMG recordings.

High-intensity training or competition is associated with mental fatigue and a generalized worsening of the state of mind.[16–19] Post-exercise massage can generate well-being, a sense of calm, a reduction in anxiety, and an improvement in mood and perceived relaxation and recovery.[1] Some authors consider that these benefits are solely related to psychological effects.[13,20,21] This issue has been explored in the sports setting by studies using the Profile of Mood States (POMS).[1,22]

One of the most widespread theoretical models on the impact of massage focuses on its analgesic effects.[21] Experience of pain is subjective and difficult to measure,[23] and varied results have been obtained on the analgesic effect of post-exercise massage.[20,24–26] Algometry pressure measurements have been successfully used to assess mechanical nociceptive thresholds (MNTs) in studies on post-exercise recovery.[27–30] We could find no published studies on the mechanical nociceptive threshold (MNT) after myofascial release in the setting of post-exercise recovery. Single applications of different modalities of massage therapy have been reported to reduce various body/mind parameters, such as state anxiety, blood pressure, and heart rate, but not negative mood, immediate assessment of pain, or cortisol level.[21] Deterioration of mood state has been associated with motor performance.[31]

With this background, the present study was designed to follow the short-term effects of myofascial release on mind/body parameters. Its objective was to investigate the short-term effects of myofascial release as a recovery method after high-intensity exercise in healthy active subjects by monitoring their neuromuscular activity (surface electromyography activity [sEMG] of quadriceps), MNT, and mood state.

Methods

Subjects

Healthy active volunteers from the Sports and Exercise School and Health Sciences School of the University of Granada were enrolled in this study from October 2005 to March 2006. Inclusion criteria were 5–10 h/week of physical activity, no pharmaceutical drug intake in past 3 months, non-use of tobacco or other addictive substances, no signs/symptoms of disease, and no contraindication of high-intensity exercise. Sixty-eight participants were randomly se-

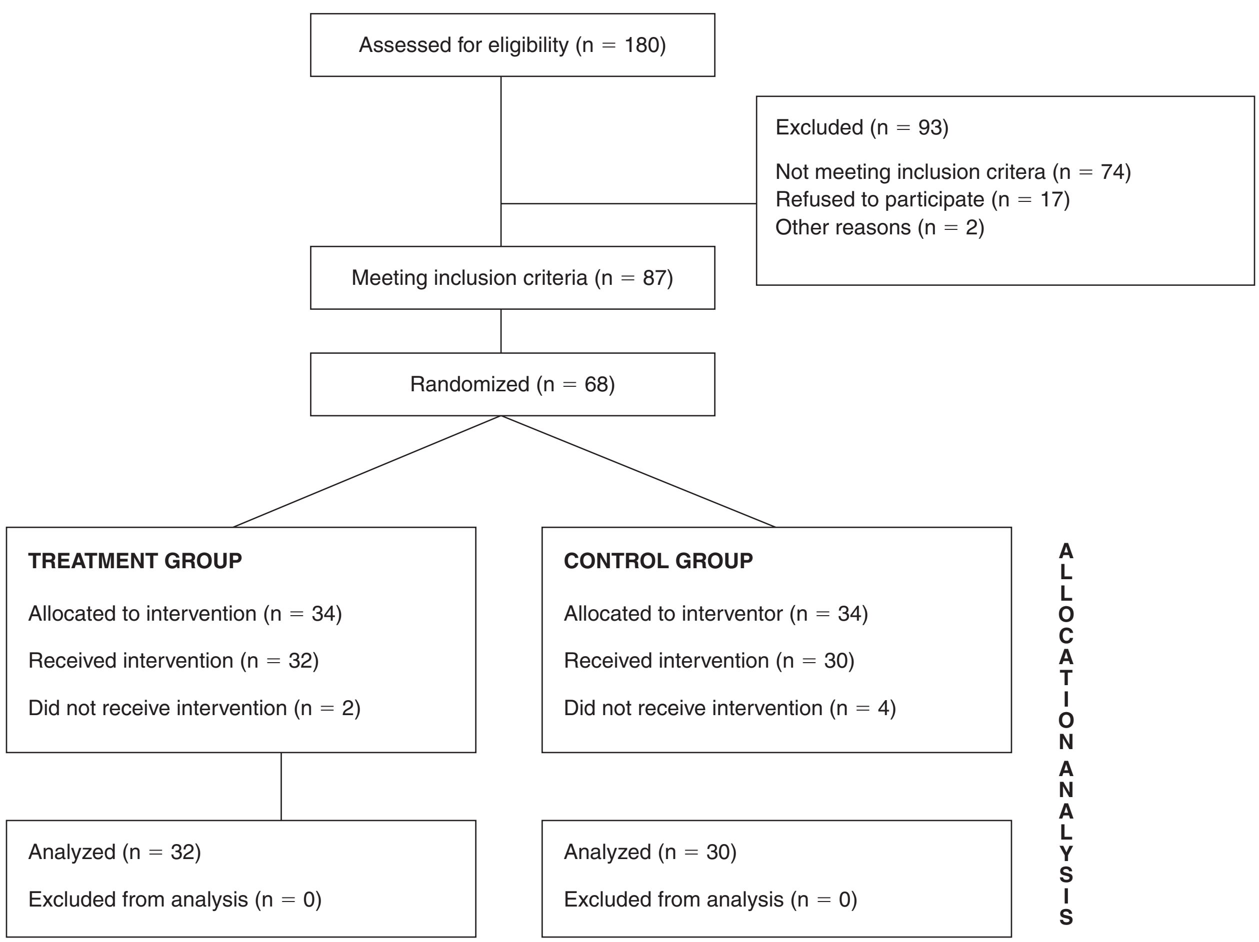

FIG. 1. Flow of participants

lected for inclusion after estimating the required sample size by using a previously reported method.[32] Written informed consent was obtained from all participants in this investigation, which was approved by the Ethics Committee of the University of Granada. The flow of participants is shown in Figure 1. The final study sample comprised 62 individuals, 37 men and 25 women, with a mean (SD) age of 21.1 (2.16) years, weight of 67.5 (1.4) kg, height of 174.3 (8.8) cm, body mass index (BMI) of 22.3 (1.4), and body fat percentage of 15.6 (5.4). Massage was part of the lifestyle of 34% of participants, was infrequently used by 58% of them, and had never been experienced by 8% of them.

Experimental design

A randomized sham-controlled study was performed using a between-group design. Subjects were assigned to massage or sham treatment by an envelope randomization method, matching the groups (treatment and sham) for sex. Volunteers entered the laboratory at the same time of day on three occasions, with a one-month interval between the first two sessions. All sessions took place between 5 p.m. and 9 p.m. At the first session, individuals underwent a medical examination (anthropometric study based on the Yuhasz-Carter skinfold method and a resting electrocardiogram [ECG]) and were screened for inclusion criteria. Familiarization was completed at the second session to ensure that all subjects knew the protocol and could complete the tasks required (see below), and to establish a reference performance value for comparison with the value obtained at the third (test) session. Following the procedure adopted in a previous study,[3] the dietary intake (food and fluid) of subjects was recorded for the two days before the familiarization visit, and this intake was exactly replicated by the subjects during the two days before the final laboratory visit. Participants were instructed not to exercise heavily during the 24 h before the test. At the third session, baseline EMG, POMS, and MNT measurements were obtained after a 10-min rest in supine position. Subjects then performed a standardized light warm-up protocol, followed by three 30-s Wingate tests on an ergometer cycle (Monark™ 834, Varberg, Sweden) according to a previously published protocol.[33] Wingate tests were separated by 3-min recovery periods. Each exercise test was performed against a braking force of 4.41 J $\cdot$ pedal revolution^{-1} $\cdot$ kg body weight^{-1}. For safety reasons and to improve exercise tolerance, the 3-min recovery periods were divided between an initial active recovery phase (pedaling at a controlled 50 W work rate for 90 s) and a subsequent passive recovery phase (90 s quiet sitting). After the third Wingate test, there was a 15-min period of active and passive recovery (10-min active/5-min passive). Subjects were encouraged to give their maximum performance during the exercise protocol and were offered an incentive (lottery ticket) if they improved on their performance in the familiarization (second) session. Electromyographic, POMS, and MNT measurements were obtained upon completion of the exercise protocol.

Immediately after the above determinations, subjects underwent sham or massage treatment. Disconnected ultrasound and magnetotherapy equipment was used for the 40-min sham treatment, whereas the massage consisted of a whole-body myofascial release treatment lasting around 40 min (according to the tissue response observed) using the Barnes & Upledger approach[34,35] (Table 1). The aim of this massage approach was to influence the deleterious psychological and physiological effects of the exercise protocol used. The position of the patient and the areas treated were identical in the two protocols. All massages were administered by the same chartered physiotherapist using conventional oil (sweet almond oil, Acofarma) when necessary. Electromyogram, POMS, and MNT measurements were obtained immediately after the intervention.

sEMG procedure

Surface electromyography activity was used to quantify muscle activation of the vastus medialis (VM), vastus lateralis (VL), and rectus femoris (RF) muscles. Biometrics EMG hardware and software (Gwent, UK) were used. Electromyography signals were obtained by means of a Datalink EMG sensor SX320 (Biometrics) and were analyzed with Datalink version 3.0 software (Biometrics). Data were high-pass filtered at 60 Hz. Parameters were as follows: bandwidth 15–450 Hz, input impedance 2 MΩ (differential), common mode rejection ratio 92 dB, maximum input voltage $\pm$ 3 V, sampling rate 1,000 Hz and gain 1,000. The EMG procedure was as previously reported.[36] Subjects performed one weight-bearing isometric maximal voluntary contraction (MVC) with their dominant limb (uniplanar knee extension). Three 5-s trials of each exercise were performed, separated by 2-min rest periods. Electromyography data for each muscle were integrated and the maximum root mean square (RMS) activity over a 0.5-s window was calculated for each trial. Data were not normalized because all comparisons made in this study were within-day.

MNT procedure

The MNT was measured by means of a pressure algometer (Wagner Instruments FPI 10). The tip of the algometer

Table 1. Massage-Myofascial Induction Protocol

Massage technique	*Body area*	*Approximate time (minutes)*
Long J-stroke	Gastrocnemius	3
Long J-stroke	Biceps femoris	3
Cross hand technique	Thoracolumbar fascia	12
Sustained pressure	Occipital condyles	5
V spread	Frontalis	5
Ear pull	Temporalis	4
Cross hand technique	Quadriceps	8

was applied perpendicular to the muscle, maintaining an application rate of 1 kg/s^{-1}. Subjects were instructed to make a signal immediately they experienced pain in order to establish their pain threshold.

The tip of the algometer was applied at the insertion of the superficial portion over the jaw angle (superficial masseter muscle) and the front-edge middle part of the upper trapezius muscle. These muscles are especially susceptible to increased contraction in response to different types of stress.[37,38] These points on the muscles were marked with a yellow label to ensure that exactly the same sites were always used. The same professional operated the calibrated algometer in all cases, using the same rate of pressure for each measurement.

POMS

The Profile of Mood States questionnaire (Spanish version software)[39] consists of 65 items on mood state. Scores (on a five-point scale of 0–4) are grouped into six subscales: Tension-Anxiety, Depression-Dejection, Anger-Hostility, Vigor, Fatigue, and Confusion. Subscale scores were converted into T-scores for the statistical analysis, and the overall mood disturbance was also calculated.

Statistical analysis

A repeated-measures design was used with two fixed effect factors (treatment group and time) and a random effect factor (participants) nested in group. The classic analysis of this repeated-measures design was not indicated because the sphericity hypothesis was not met in many cases; therefore a generalized estimating equations (GEE) model was used.[40] The model included two main effects (group and time) and the interaction of these effects. We could find no published studies on this topic, to avoid losing any relevant effects, we considered the interaction to be significant at $p < 0.10$. If the interaction was not significant, we performed a main effects comparison of exercise to baseline with application of the Bonferroni correction. When the interaction was significant, comparisons were made between groups at each time point and between time points for each group, using the Bonferroni correction. When necessary, data were log-transformed to achieve homogeneity of variance. In the comparisons, $p < 0.05$ was regarded as significant. The STATA 9.1 package (Stata Corp., College Station, TX) was used for the statistical analysis.

Results

sEMG

After the exercise protocol, the two groups showed a significant increase in the EMG amplitude of VM ($p < 0.001$), VL ($p < 0.01$, and RF ($p < 0.05$) (Table 2). Generalized estimating equations model analysis showed a significant effect of group x time interaction on VM ($p = 0.02$). The EMG of VM did not significantly differ between groups at baseline ($p = 0.22$). The EMG of VM was significantly lower versus baseline after massage treatment ($p = 0.02$) but not after sham treatment ($p = 0.32$). The EMG of VL ($p = 0.20$) and RF ($p = 0.33$) did not significantly differ between groups at baseline. Recovery changes in VL and RF were not analyzed because no significant effects of their interaction were observed in the GEE model analysis.

POMS

Generalized estimating equations model analysis showed significant effects of group $\times$ time on vigor ($p = 0.04$) and confusion ($p < 0.10$) (Table 3). There was no significant difference in vigor between groups at baseline ($p = 0.75$), and both groups showed a significant reduction in vigor after the exercise protocol ($p < 0.001$). Vigor was significantly lower than at baseline ($p \leq 0.01$) after the recovery with massage but similar to the baseline value after the sham treatment ($p = 0.86$). There was no significant difference between groups in confusion ($p = 0.93$), and a significant increase in confusion was observed after exercise protocol in both sham ($p = 0.04$) and treatment ($p < 0.001$) groups. After the re-

TABLE 2. COMPARISON OF sEMG BETWEEN GROUPS AT DIFFERENT STUDY TIME POINTS[a]

	Sham group (n = *30*)	*Massage group* (n = *32*)	p-*value**
Vastus medialis (mV)			
Baseline	290.8 ± 185.7	349.5 ± 198.9	
Exercise	399.5** ± 181.4	482.5** ± 293.4	0.02
Recovery	318.0 ± 194.8	293.6† ± 180.3	
Vastus lateralis (mV)			
Baseline	171.6 ± 149.1	213.0 ± 186.3	
Exercise	210.4** ± 156.5	266.3** ± 131.8	0.75
Recovery	201.6 ± 97.2	226.6 ± 105.7	
Rectus femoris (mV)			
Baseline	158.9 ± 96.5	190.2 ± 152.7	0.53
Exercise	178.3** ± 87.1	258.1** ± 191.2	
Recovery	186.6 ± 146.4	228.4 ± 143.5	

[a]Data are expressed as geometric mean ± standard deviation. The values at different time points were tested by generalized estimating equations (GEE).

**p*-value for interaction effect between group and time by GEE analysis.

***$p < 0.05$ between baseline and exercise measurements †$P < 0.05$ for within-group comparisons to baseline (for variables with significant interaction), using the Bonferroni correction.

sEMG = surface electromyography activity (mV).

TABLE 3. COMPARISON OF PROFILE OF MOOD STATE (POMS) AND ALGOMETRY OF MASSETER FOR GROUPS AT DIFFERENT MOMENTS DURING STUDY[a]

	Sham group	*Massage group*	p
Tension			
Baseline	43.3 ± 8.5	43.3 ± 7.9	
Exercise	40.9 ± 7.1	42.5 ± 7.3	0.21
Recovery	32.9 ± 3.8	30.8 ± 3.8	
Depression			
Baseline	45.9 ± 7.9	44.3 ± 7.3	
Exercise	45.7 ± 8.9	45.4 ± 7.2	0.61
Recovery	40.8 ± 4.9	40.9 ± 3.9	
Anger			
Baseline	50 ± 10.6	47.2 ± 9.3	
Exercise	47.4 ± 9.3	46.9 ± 9.1	0.64
Recovery	42.3 ± 4.7	40.2 ± 3.7	
Vigor			
Baseline	54.6 ± 8.7	55.2 ± 6.2	
Exercise	47.7** ± 7.1	42.8** ± 7.6	**0.04***
Recovery	54.3 ± 7.2	50.3*,** ± 7.0	
Fatigue			
Baseline	43.0 ± 6.7	44.0 ± 7.9	
Exercise	56.6** ± 9.5	60.9** ± 8.0	0.15
Recovery	43.0 ± 5.8	42.5 ± 7.3	
Confusion			
Baseline	36.9 ± 7.5	37.0 ± 7.0	
Exercise	39.8** ± 8.6	43.6** ± 8.1	**0.10***
Recovery	32.7**,* ± 4.1	34.3 ± 4.1	
Mood disturbance			
Baseline	16433.3 ± 3657.5	16034.4 ± 4092.7	
Exercise	18350.0 ± 4008.8	19653.1 ± 3566.1	0.23
Recovery	13740.0 ± 1782.7	13834.4 ± 1887.9	
Masseter (Kg/cm^2)			
Baseline	2.1 ± 0.6	2.1 ± 0.7	
Exercise	1.9** ± 0.6	1.9** ± 0.6	0.20
Recovery	2.1 ± 0.5	2.2 ± 0.6	
Upper trepezius (Kg/cm^2)			
Baseline	2.5 ± 0.8	2.6 ± 0.9	
Exercise	2.3** ± 0.9	2.3** ± 0.7	0.60
Recovery	2.5 ± 0.8	2.7 ± 0.9	

[a]Data are expressed as mean ± standard deviation. The values at different moments were tested by generalized estimating equations. *$p < 0.10$, **$p < 0.05$, respective baseline measurements.

covery strategy, confusion showed a significant decrease versus baseline ($p < 0.01$) in the sham group, whereas there was no significant difference versus baseline ($p = 0.05$) in the massage group (Table 3).

MNT

According to the GEE analysis, massage had no significant effect on MNT in the masseter ($p = 0.20$) or trapezius ($p = 0.60$) muscles. In both groups, MNT in the trapezius and masseter muscles significantly decreased ($p < 0.001$) after the exercise protocol but was similar ($p = 0.30$) to the baseline value at the end of the recovery intervention (Table 3).

No gender or age differences were observed in the massage or sham treatment effects studied (data not shown).

Discussion

This study offers the first demonstration that massage therapy, applied as a passive recovery strategy after intensive exercise, reduces the EMG amplitude of VM during maximum voluntary contraction, i.e., the maximum electric activity needed to perform this contraction.[41] Electromyography amplitude has been associated with muscle strength[3,10] and with the relationship between muscle fiber tension and length, and it has been found that acute and chronic massage treatment can increase muscle fiber length (stretching).[42] It is possible that, in our study, the muscle fiber length–tension relationship was modified by the massage treatment, reducing the EMG amplitude. A change in muscle fiber length with a transient loss of muscle strength may be related to a change in muscle architecture.[10] It has recently been proposed that the mechanisms of myofascial release (transegrity, thixotropism) are based on changes to the architecture and functional state of the myofascial system.[43] A parasympathetic vegetative response associated with massage-induced improvements in heart rate variability, blood pressure,[32] and immune function[44] may produce a local muscle response characterized by a decrease in motor unit action potential amplitude and motor unit firing rate.

The intermittent submaximal exercise protocol used in our study proved adequate to increase the EMG amplitude of

VM, VL, and RF, compatible with local muscle fatigue.[45,46] Reports on EMG activity after a single Wingate test have been controversial, with one study describing a decrease[47] and another maintenance[10] of the amplitude of VM and VL. Our outcomes are consistent with previous findings of an increase in EMG amplitude after completion of a similar protocol,[48] indicating that repeated Wingate tests can induce transient local muscle fatigue. The increased EMG amplitude detected in our study may be linked to physiologic events related to muscle fiber protection mechanisms in fatigue conditions.[10,11]

Following the same research line as other authors on the psychological effects of massage[1,13] this study confirms a previous report[20] that massage therapy does not induce positive mood state changes, at least in the short term, but reduces deleterious effects induced by high-intensity exercise. In the massage group, vigor decreased after exercise and then increased after recovery but to a level below the baseline value and the members of that group showed higher confusion levels than at baseline, unlike sham-treated subjects. Some authors associated a decrease in vigor and an increase in confusion with a reduction in sports performance.[49,50] Taken together, these findings support previously held ideas[51] that, to avoid any negative effects on performance, recovery massage protocols should not be applied before a competition. Lack of vigor and a tendency to confusion may indicate a subjective perception of the relaxation state generally induced by massage therapy. This state may be related to the ability of this type of manual therapy to restore balance to the autonomic nervous system after intermittent high-intensity exercise.[32]

In common with other authors, we found that massage has no effect on pain perception.[2,24] Likewise, our massage protocol does not appear to have any impact on the exercise-induced increase in MNT, which can spontaneously recover after a few minutes.[52] We expected an increase in MNT to be associated with the relaxation induced by our massage protocol.[32] New research on the MNT of muscles involved in exercise would be of interest to examine the relationships among psychological state, physiological state, and pain perception.

Study limitations include the absence of a direct evaluation of strength during the EMG recording. To assess the value of massage therapy for local recovery, future studies should explore whether the EMG decrease is associated or not with preservation of the strength developed during a maximal isometric contraction. A longer follow-up (e.g., 24–48 h) of massage-induced psychological changes would also be of interest to test the proposition that massage should be avoided in the two days before a competition. Strengths of the study are the good control and standardization measures adopted, overcoming some of the methodological limitations (control group conditions, sample size) of some previous studies on the effects of massage therapy.[2,21] Our experience suggests the need for studies that use a within-group design in order to reduce the variability in results.

In conclusion, the application of massage as a passive recovery strategy after high-intensity exercise reduces the EMG amplitude of VM during MVC and reduces vigor with respect to pre-exercise values.

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Disclosure Statement

No competing financial interests exist.

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