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ORIGINAL RESEARCH

Lower Amplitude of the Hoffmann Reflex in Women With Patellofemoral Pain: Thinking Beyond Proximal, Local, and Distal Factors

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Abstract

Objectives: To investigate whether vastus medialis (VM) Hoffmann reflexes (H-reflexes) differ on the basis of the presence or absence of patellofemoral pain (PFP) and to assess the capability of VM H-reflex measurements in accurately discriminating between women with and without PFP.

Design: Cross-sectional study.

Setting: Laboratory of biomechanics and motor control.

Participants: Women (N=30) aged 18 to 35 years were recruited, consisting of 2 groups: women with PFP (n=15) and asymptomatic controls (n=15).

Interventions: Not applicable.

Main Outcome Measures: Maximum evoked responses were obtained by electrical stimulation applied to the femoral nerve, and peak-to-peak amplitudes of maximal Hoffmann reflex (Hmax) and maximal motor wave (Mmax) ratios were calculated. Independent samples *t* tests were performed to identify differences between groups, and a receiver operating characteristic curve was constructed to assess the discriminatory capability of VM H-reflex measurements.

Results: VM Hmax/Mmax ratios were significantly lower in participants with PFP than in pain-free participants ($P=.007$). In addition, the VM Hmax/Mmax ratios presented large and balanced discriminatory capability values (sensitivity, 73%; specificity, 67%).

Conclusions: This study is the first to show that VM H-reflexes are lower in women with PFP than in asymptomatic controls. Therefore, increasing the excitation of the spinal cord in PFP participants may be essential to maintaining the gains acquired during the rehabilitation programs.

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Patellofemoral pain (PFP) is a common condition in orthopedic practice.[1] Women are 2.23 times more prone to PFP than are men,[2] and the estimated prevalence of PFP in women aged 18 to 35 years is 13%.[3] The main symptom of this disorder is pain around the patella, and its etiology remains obscure despite the large amount of associated biomechanical alterations that have been reported.[4]

Several factors have been proposed in an attempt to explain the pathomechanisms underlying PFP. The consensus statements from the most recent international conferences grouped PFP-associated biomechanical alterations into 3 mechanistic categories: proximal factors, distal factors, and local factors.[5] Local factors include

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delayed onset of the vastus medialis (VM)[6] and weakness of quadriceps muscles.[7] Examples of proximal factors are excessive hip internal rotation, hip adduction,[1,8] and hip muscle weakness.[9,10] Lastly, distal factors such as excessive rearfoot eversion range of motion[11] have also been proposed.[12]

Although it is generally agreed that the etiology of PFP is multifactorial in nature, little attention has been paid to its putative neurophysiological factors. For instance, subjects with knee osteoarthritis, a possible progression of PFP,[13,14] showed quadriceps weakness and diminished knee proprioceptive acuity.[15] This suggests that abnormal afferent sensory information from the injured knee joint may reduce excitability of the α-motor neurons, thereby inducing quadriceps inhibition. However, this theory is yet to be supported by direct neurophysiological measurements so as to provide a real picture of the mechanisms underlying the sensorimotor changes reported.

In this vein, the Hoffmann reflex (H-reflex), the electrical homologous of the stretch reflex, has been used in research and clinical settings in an attempt to better understand how the central nervous system integrates the descending signals with those coming from the periphery.[16] It has been used as an indirect measurement of spinal excitability, thereby probing the response of the nervous system to neuropathies (eg, polyneuropathies and spasticity)[17,18] or exercise (eg, training and fatigue).[19] However, to our knowledge, no study has evaluated the H-reflex excitability in participants with PFP. Such an investigation will shed light on our understanding of the mechanisms associated with the development of PFP.

We hypothesized that the amplitude of the VM H-reflex would be lower in subjects with PFP than in control subjects (ie, without PFP). Therefore, the first purpose of this study was to investigate whether VM H-reflexes differ on the basis of the presence or absence of PFP. Because PFP is multifactorial in nature, it would also be important to investigate the rate of true positives/negatives and false positives/negatives obtained by using H-reflex measurements as a discriminatory tool, so as to provide a real picture of the proportion of subjects with PFP who indeed show impaired H-reflex excitability. Therefore, the second objective of this study was to assess the capability of VM H-reflex measurements in discriminating between women with and without PFP.

Methods

Participants were recruited from gyms (contact with owners and flyers distribution), parks (flyers distribution), and universities (advertisements before classes and flyers distribution), between February 1 and November 30, 2014. The study was approved by the local ethics committee, and each participant gave written informed consent before participation.

List of abbreviations:

Hmax	**maximal Hoffmann reflex**
H-reflex	**Hoffmann reflex**
ICC	**intraclass correlation coefficient**
Mmax	**maximal motor wave**
PFP	**patellofemoral pain**
ROC	**receiver operating characteristic**
VM	**vastus medialis**

Table 1 Demographic characteristics of the subjects

Variable	Pain-Free	PFP	*P*
Age (y)	23.67±3.75	22.07±3.17	.218
Body mass (kg)	59.87±8.53	55.73±4.48	.111
Height (m)	1.65±0.04	1.64±0.06	.711
Worst pain level in the previous month (VAS)	NA	4.80±0.40	NA
Average duration of the symptoms (mo)	NA	66.20±12.51	NA

NOTE. Values are mean ± SD.
Abbreviations: NA, not applicable; VAS, visual analog scale.

Participants

Thirty women aged 18 to 35 years were recruited, consisting of 2 groups: PFP group (n=15) and control group (n=15). The demographic characteristics of the participants are presented in table 1. Power calculations for this study were performed using preliminary data (pilot study) from our laboratory. Sample size was determined on the basis of predicted power to detect a difference of .12 (SD=.17) in VM maximal Hoffmann reflex (Hmax) normalized by the maximal motor wave (Mmax; Hmax/Mmax ratios) between groups, considering an α level of .05 and a power of 80%. Based on the calculations performed with SamplePower software,[a] a minimum sample size of 9 subjects per group was indicated. Diagnosis of PFP was completed after consensus among 2 experienced clinicians (>5y of experience) and on the basis of definitions used in previous PFP studies.[11,20-22] The inclusion criterion screened by clinicians was pain during patellar palpation. In addition, subjects needed to fulfill all the following requirements to be included in the PFP group: (1) report symptoms of insidious onset and duration of at least 1 month; (2) peri- or retropatellar pain during at least 2 of the following activities: squatting, prolonged sitting, kneeling, running, jumping, and climbing stairs; and (3) worst pain level in the previous month of up to 3cm on a 10-cm visual analog scale. To be included in the control group, participants could not present any signs or symptoms of PFP or other musculoskeletal condition. The presence of the following conditions was screened for both groups: lower limb inflammatory process, patellar subluxation or dislocation, patellar tendon or meniscus tears, bursitis, and ligament tears. Those who had undergone knee surgery, oral steroids, or acupuncture were excluded from this study. In addition, participants who had received physiotherapy during the preceding 6 months were excluded.

H-reflex stimulation and recording

Electromyograms were recorded using round-shaped adhesive surface electrodes (Ag/AgCl electrodes,[b] 0.8cm in diameter, with an interelectrode distance of 2 cm) applied in bipolar configuration over the VM muscle. The electrodes were placed distally at the longitudinal axis of the femur in line with the orientation of VM fibers, 2cm distally to the motor point in the direction of the muscle belly. Electromyographic signals were amplified (final gain of 1000×) and filtered (fourth-order Butterworth filter with cutoff frequencies set at 5 and 2000Hz) using an MSC 1000 V3 system,[c] with a common rejection mode ratio of >130dB, an input