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学 位 論 文 題 目	Anticipatory postural adjustments during a reaction time task and their reorganization due to knee pain
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（様式３）

Summary of Doctoral Thesis

Name in full　Shiozawa, Shinichiro

Title Anticipatory postural adjustments during a reaction time task and their reorganization due to knee pain

Introduction

Musculoskeletal disorders, including knee pain, are becoming one of the main issues in the public health systems of several countries, as evidenced by the current situation in Japan because elderly people require continuous nursing care as a result of regular falls and musculoskeletal disorders. Hence, the present knee pain-related human postural control study not only sought to clarify changes in the neural mechanism of postural control, but also has the potential to contribute knowledge to the public health system.

Objective

Aim of the project is to examine the influence of experimental knee-related pain on anticipatory postural adjustments (APAs) related to reaction time tasks in healthy adults without pathological factors (Figure).

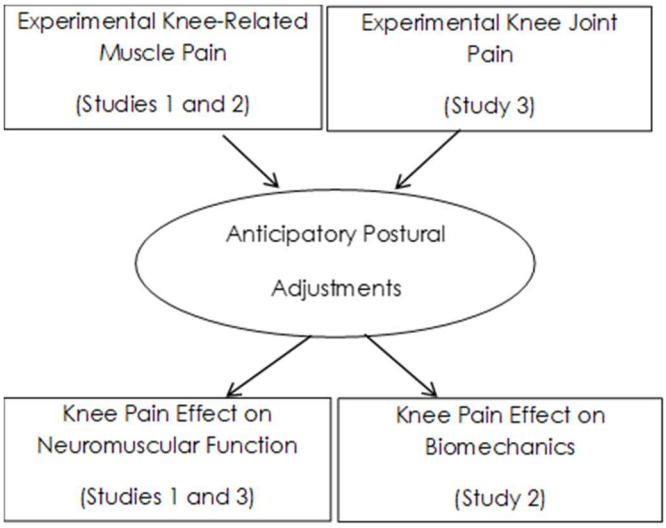

Figure: Model of the interaction between knee-related pain and APAs investigated in this project.

Materials and methods

Induced knee-related pain due to hypertonic saline injection into muscles (Studies 1 and 2) and the infrapatellar fat pad (Study 3) were used. Knee pain effects on APAs were detected by assessing neuromuscular function (Studies 1 and 3) and by biomechanical measurements (Study 2). All participants were healthy volunteer.

Results

Study 1, it was shown that vastus medialis (VM) pain induced an earlier activation onset (relative time from the onset of target muscle movement) of the ipsilateral biceps femoris during shoulder flexion task than in the no-pain condition. The onset of the target muscle movement in the shoulder flexion task did not change under the pain condition. Peak angle and peak angular velocity of the shoulder joints in the pain condition also demonstrated no change. VM and tibialis anterior (TA) pain induced by hypertonic saline injection caused earlier onset of contralateral TA activation during bilateral heel lifts task than seen under the no-pain conditions. In the bilateral heel-lift task, VM pain reduced the peak muscle activity of the bilateral VM and the ipsilateral vastus lateralis (VL) as compared with the no-pain conditions, whereas TA pain resulted in a greater reduction in

the peak muscle activity level of the ipsilateral VM and the ipsilateral TA than in the no-pain conditions.

Study 2, we found that experimental TA pain reduced the net centre of pressure (CoP) displacement in the medial-lateral (ML) direction between the first and second peak values during APAs during a shoulder flexion task, as compared to the no-pain condition. Muscle pain also reduced displacement of the ipsilateral side CoP in the anterior-posterior direction as compared to the no-pain condition. CoP displacement on the contralateral side during the same task showed no change. The onset time of arm movement during shoulder flexion in the pain condition was not changed as compared to the no-pain condition.

Study 3, infrapatellar fat pad pain caused earlier activation onset (relative time from the onset of the target muscle movement) of the contralateral VM during a bilateral heel-lift task than under the no-pain condition. The pain in the same task also induced a longer delay in activation onset of the ipsilateral VM, the ipsilateral VL, and the ipsilateral TA than under the no-pain condition. In the same three muscles during the same task, the pain reduced the muscle activity level (muscle activity between the “Go signal” and 500 ms was isolated for each 50 ms and was evaluated by EMG), as compared to the no-pain condition. Early onset of postural muscle activation during APAs occurred on the non-painful side, while delayed onset of activation and reduced activity level of the postural muscles during APAs were seen on the painful side. Nevertheless, the activation onset of the bilateral soleus, the bilateral peak angle, and bilateral peak angular velocity during the bilateral heel-lift task under the pain condition did not change.

Discussion

Knee-related deep tissues pain indicated to induce a reduction in muscle activity levels, and delayed the activation onset of these muscles and cause early onset of activation of postural muscles during APAs. Reduced muscle activity levels and delayed activation onset of postural muscles during APAs occurred on the painful side or aspect, while early activation onset occurred

in the non-painful muscles. These results suggest the importance of APA mechanisms to maintain standing posture during reaction time tasks. This implies that the mechanism of postural control provides reasonable compensation for feed-forward postural control. During knee-related deep tissue pain, APA achieves: 1) protection of painful or related tissues or joints from secondary damage, as a pain-adaptation strategy, 2) maintenance of the standing posture, using a compensatory strategy, and 3) avoidance of falling and an unstable standing posture. Furthermore, bilateral CoP and net CoP displacement are reasonable biomechanical parameters by which to detect the effect of knee-related pain during APAs.

Overall, these results suggest that pain in knee-related deep tissues reorganizes APAs and induces an altered strategy for postural control during reaction time tasks.

Form8 : Separate Sheet
（様式８・別紙１）

Results of the doctoral thesis screening

博士論文審査結果

Name in Full
氏　　名　　塩澤　伸一郎

Title
論文題目　　Anticipatory postural adjustments during a reaction time task and their reorganization due to knee pain

膝関節周囲の痛みを伴う変形性膝関節症は加齢とともに増加し、姿勢制御をはじめとする運動制御が障害される。このため、膝関節関連の疼痛は高齢者の日常生活における転倒等のリスクにつながり、公衆衛生上の大きな問題となっている。そこで、申請者は健常者の膝関節や膝関節周囲の筋に疼痛を実験的に起こす手法を開発し、反応時間課題を用いることにより、疼痛がフィードフォワード的な予測姿勢制御へ及ぼす影響について調べた。

研究１では、高張食塩水を内側広筋または前脛骨筋に注入することで実験的疼痛を誘発した。コントロール条件では、疼痛を誘発しない等張食塩水を注入した。音刺激に対して、片側肩関節屈曲あるいは両側踵挙上を行うという反応時間課題を課し、筋電図を計測した。肩関節屈曲課題では、疼痛を誘発した筋と対側の内側広筋の筋活動の開始がコントロール条件に比べて早期化した。両側踵挙上課題では、内側広筋の疼痛条件、及び、前脛骨筋の疼痛条件で疼痛側と対側の前脛骨筋の筋活動開始が早期化した。また両側踵挙上課題では、両側の内側広筋、同側の外側広筋の筋活動のピークが疼痛条件でコントロール条件に比べて低下した。前脛骨筋の疼痛条件では、同側の内側広筋と前脛骨筋の活動量が減少した。

研究２では、同様な方法で疼痛を誘発して、バイオメカニクス的観点から立位時の圧力中心の変化を調べた。肩関節屈曲課題では、前脛骨筋の疼痛条件で、コントロール条件に比べて、左右方向の圧中心の軌跡長が減少した。また、前脛骨筋の疼痛条件でコントロール条件に比べて、予測性姿勢制御を反映する疼痛側と同側の圧力中心の前後方向の変位の軌跡長が減少した。疼痛を誘発した筋と対側の圧力中心は変化を見せなかった。

研究３では、高張食塩水を膝蓋下脂肪体に投与し膝関節疼痛を誘発した。両側踵挙上課題の疼痛条件では、コントロール条件に比べて疼痛側と対側の内側広筋の活動開始が早期化した。同側の内側広筋･外側広筋･前脛骨筋の活動開始が遅延し、同側の筋活動量はいずれも減少した。

これらの研究結果から、フィードフォワード的な予測的姿勢制御における疼痛側と同側の筋活動量の低下、姿勢保持のための対側筋の活動の早期化などの姿勢制御の再編成が、新たな知見として得られた。また、これらの筋活動や圧力中心に関する指標は、疼痛の影響、身体活動、リハビリ介入などを評価するバイオマーカーとなりうることも示された。本研究は、予測的姿勢制御と膝関節の疼痛との関連に関して重要な知見を提供している。３本の原著論文が国際誌に出版済みであり、論文博士としての学位取得条件を満たしている。以上の理由により、審査委員会は、全員一致で本論文が学位の授与に値すると判断した。