Higher grip strength increases the risk of incident radiographic osteoarthritis in proximal hand joints

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Summary

Quadriceps strength may protect against knee osteoarthritis (OA), but muscle activity is a major determinant of forces at the hand joints. Gripping objects is a common task during which high muscular forces are sustained, particularly at the proximal hand joints (metacarpophalangeal (MCP) joints and thumb base). The association between maximal grip strength and incident OA at different hand joints was examined in a longitudinal study of radiographic hand OA.

Subjects with higher maximal grip strength were at increased risk for development of OA in the proximal interphalangeal (PIP) joints, MCP and thumb base joints in men; and in the MCP in women. No association was found between maximal grip strength and incident distal interphalangeal (DIP) joints OA in men or women. The conclusion is that increased grip strength, which is the major force of loading across proximal hand joints, increases the risk of OA in those joints. © 2000 OsteoArthritis Research Society International

Key words: Hand OA, Grip strength, Radiologic OA.

Introduction

Cross-sectional studies have shown that hip abductor and quadriceps muscles are weaker in those with hip or knee osteoarthritis (OA) than in people without OA,1,2 which is consistent with biomechanical studies that have demonstrated that muscle often serves to attenuate joint load.3 However, even at the hip or knee, certain patterns of muscle activity may result in increased joint load.4-7 On a regular basis, these patterns could theoretically contribute to the development and progression of OA.

The major determinant of forces at the hand joints is muscle activity.8 Grip is a common task during which high muscle force is sustained in certain hand joints.9 The measurement of maximal grip strength can provide a global measure of the magnitude of muscular force a subject can generate during a common activity. Several studies of hand biomechanics have demonstrated that forces generated at the distal interphalangeal (DIP) joints during grip are substantially less than the forces at proximal interphalangeal joints (PIP), metacarpophalangeal (MCP) and carpometacarpal (CMC) joints.10,11

We utilized longitudinal hand X-rays in a population-based group of individuals to evaluate the relation between maximal grip strength and the development of hand OA. Further, we evaluated whether the relation of maximal grip strength to hand OA differs by joint group.

Methods

SUBJECTS

Study subjects were members of the Framingham Cohort, a population-based group seen biennially since 1948. Baseline radiographs of the right hand were taken in 1967–1969 (Framingham Exam 10), and a follow-up radiograph of both hands was performed approximately 24 years later in 1992–1993 (Framingham Exam 22).12,13

Maximal grip strength in kilograms was assessed in Framingham subjects at biennial examinations 5 (1957–1959), 6 (1958–1961) and 7 (1960–1963) using an adjustable, hand held dynamometer. A single grip strength measurement was obtained for each hand at each examination.

X-RAY READINGS

Baseline and follow-up radiographs were read in a paired manner and each joint was graded for the presence of individual radiographic features according to a modified Kellgren and Lawrence (K&L) 0–4 scale.

DEFINITIONS OF VARIABLES

Because prevalent hand OA could affect grip strength, we restricted our evaluation to subjects with no radiographic hand OA in any right hand joint at baseline (i.e. no hand joint with K&L score ≥2). We used only the right hand because the left was not X-rayed at baseline. Incident OA was defined for each joint as the development of a K&L grade 2 or greater in that joint. We examined four different joint groups in the hand: four DIP joints, four PIP joints, four MCP joints (excluding the thumb MCP), and base of thumb (scaphotrapezial and scaphoid-metacarpal combined). The thumb MCP and interphalangeal joints were not included.

OTHER VARIABLES

We adjusted for activity by using the Framingham physical activity index (PAI) and for occupational status by
broadly dividing jobs into eight categories (professional, executive, supervisor, technical, laborer, clerical, sales and housewife) using the Dictionary of Occupational Titles.

ANALYSIS

Because of the marked differences in both grip strength and OA incidence by gender all analyses were gender-specific. Grip strength was divided into gender-specific tertiles and the lowest grip strength tertile served as the reference group.

We examined crude cumulative incidence of hand OA over the 24-year follow-up period for each joint group (i.e. DIP, PIP, etc.). In addition, we calculated the risk of incidence of OA in each of the four groups of hand joints over the follow-up period for each tertile of maximal grip strength. To assess the effect of maximal grip strength on the risk of hand OA we performed joint-based analysis by using the generalized estimating equation (GEE) method.\textsuperscript{14,15} The GEE method, which uses each joint as the unit of analysis while accounting for the correlation between multiple joints in an individual, produces valid estimates of association between exposure and disease. All GEE analyses were adjusted for age and physical activity index and job category. A test for trend was done using the grip strength tertiles as ordinal variables.

Results

Our analysis was restricted to 746 subjects with baseline and follow-up hand X-rays. Of these, we found 456 with no prevalence of radiographic OA in any right hand joint at baseline. Three subjects were missing grip strength data and were dropped from the analysis, leaving 453 subjects eligible for our study.

The 453 (173 men, 280 women) subjects were similar in baseline age (men 54±5, women 53±5), but differed in grip strength in that men had stronger maximal grip (Table I). The majority of women were housewives (71%), while the men tended to be laborers (35%), supervisors (24%) or professionals (17%) (Table I).

We examined the relation between incidence of hand OA and baseline grip strength. Grip strength in kilograms was divided into gender specific tertiles (men: low=32.5-44.5 kg; middle=45-52.5 kg; high=53-67 kg; women low=12-23.5 kg; middle=24-27.5 kg; high=28-40.5 kg).

Table I: Baseline characteristics of study participants (in 13)

<table>
<thead>
<tr>
<th></th>
<th>Men</th>
<th>Women</th>
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</thead>
<tbody>
<tr>
<td>Age: Mean (s.d.)</td>
<td>54 (5)</td>
<td>53 (5)</td>
</tr>
<tr>
<td>Physical activity index: Mean (s.d.)</td>
<td>36 (5)</td>
<td>34 (4)</td>
</tr>
<tr>
<td>Maximal grip strength (kg): Mean (s.d.)</td>
<td>49 (7)</td>
<td>26 (5)</td>
</tr>
<tr>
<td>Job category: (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Professional/Executive</td>
<td>17%</td>
<td>5%</td>
</tr>
<tr>
<td>Supervisor</td>
<td>24%</td>
<td>3%</td>
</tr>
<tr>
<td>Technical</td>
<td>8%</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>Laborer</td>
<td>35%</td>
<td>9%</td>
</tr>
<tr>
<td>Clerical</td>
<td>5%</td>
<td>9%</td>
</tr>
<tr>
<td>Sales</td>
<td>8%</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>Housewife</td>
<td>NA</td>
<td>71%</td>
</tr>
<tr>
<td>Job unknown</td>
<td>2%</td>
<td>1%</td>
</tr>
</tbody>
</table>

s.d. = standard deviation.

We found no association between maximal grip strength at baseline and the likelihood of developing hand OA in the DIP joints at follow-up in either men or women [Fig. 1(a) and (b)]. However, in proximal joints, such as the MCP, higher grip strength was associated with an increased risk of OA. Of men in the highest grip strength tertile, 22 MCP joints (11%) developed OA compared to only 10 MCP joints (4%) in the lowest grip strength tertile. This relationship was also strong for the thumb base (16% in lowest grip tertile vs 39% in highest tertile) [Fig. 1(a)]. In women the relationship between maximal grip strength and the development of OA was similar, although not as strong as in men [Fig. 1(b)].

We evaluated the overall risk of OA by grip strength tertile in the four different hand joint groups adjusting for age, physical activity index and occupation. Maximal grip strength was not associated with the risk of development of OA in the DIP joints in either men or women. In men there was an increase in the risk of OA in the PIP joints for the highest tertile of grip strength (OR=2.8, 95% confidence interval (CI) 1.2, 6.7) [Fig. 2]. In women we did not find an association between grip strength and PIP OA (Fig. 2).

We found an association between higher maximal grip strength and the development of OA in the MCP joints both men and women (in men, P<0.05; in women, P<0.01) (Fig. 3). For men in the highest tertile of grip strength, the risk of MCP OA was significantly increased (odds ratio (OR)=2.9, 95% CI 1.1, 7.4, P=0.03). The risk was similarly increased in women in the highest tertile of grip strength (OR= 2.7,
Incident PIP OA in men and women

Incident MCP OA in men and women

Incident thumb base OA in men and women

Discussion

In summary, we found that men with high maximal grip strength had an increased risk of OA in PIP, MCP and thumb base joints. Women with a higher maximal grip strength had an increased risk of developing OA in the MCP joints and a modest increase in risk for OA in the thumb base. We found no association between maximal grip strength and incident DIP OA in men or women.

The lack of association between maximal grip strength and OA in the DIP joints is not surprising as high forces at this site are attained during pinching, rather than grasping which tends to load the proximal joints. An et al. demonstrated that the compressive force across the articular surface is much higher in the PIP and MCP joints than in the DIP during grasp, briefcase grip, holding a glass or opening a jar. During the grasping motion, compression forces have been shown to rise dramatically from the interphalangeal joint of the thumb to the first MCP to the first CMC joint. Compression forces as high as 120 kg may occur at the CMC joint during a 'strong' grasp. In a study of occupational hand OA, Hadler et al. found that workers performing tasks involving a powerful grip had significantly less OA in the DIP joints than did workers performing tasks involving precision grip. Consistent with our findings, Hochberg et al. found, after adjusting for age, no association between grip strength and prevalent DIP OA.

We found a stronger association between grip strength and risk of OA in men than in women. It is well established that men have much higher grip strength, which could result in increased load across the articular surface, perhaps leading to joint damage. Thus, this stronger association in men is to be expected and further suggests that excessive muscle force may contribute to the pathogenesis of hand OA.

In conclusion, individuals with higher maximal grip strength are at increased risk for development of OA in certain hand joints. Our results, combined with those of others, are consistent with the possibility that OA in a given joint results from a complex interplay of factors including joint loading.

References


