Association Between Recent Sports Activity, Sports Activity in Young Adulthood, and Stroke

Armin J. Grau, MD, PhD; Cordula Barth; Beate Geletneky; Paul Ling; Frederik Palm, MD; Christoph Lichy, MD; Heiko Becher, PhD; Florian Buggle, MD

Background and Purpose—Leisure-time physical activity protects from stroke. It is insufficiently established whether early lifetime physical activity is independently protective and whether some etiologic stroke subgroups particularly benefit from physical activity. We tested the hypothesis that both recent and early-adulthood sports activities are associated with reduced odds of stroke and analyzed their effects in stroke subtypes.

Methods—we performed a case-control study of 370 patients with acute stroke or transient ischemic attack (TIA) and 370 age- and sex-matched control subjects randomly selected from the population and assessed recent and young adulthood sports activities and their weekly duration in standardized interviews.

Results—Recent regular sports activities were less often reported by patients (94/370, 25.4%) than by control subjects (162/370, 43.8%; P<0.0001). After adjustment for vascular risk factors, education, and other factors, recent participation in sports was significantly associated with reduced odds of stroke/TIA (odds ratio=0.64; 95% CI, 0.43 to 0.96). Both groups did not differ with regard to sports activities in young adulthood. More control subjects (69/365, 18.9%) than patients (25/361, 6.9%) participated in sports recently after not having been active in young adulthood, and such a pattern was associated with reduced odds of stroke/TIA in multivariable analysis (odds ratio=0.37; 95% CI, 0.21 to 0.85).

Conclusions—Our study supports previous results that have shown stroke protection by physical activity. Results suggest that continuous lifetime activity or starting activities during later adulthood is required to reduce stroke risk. (Stroke. 2009;40:000-000.)

Key Words: stroke ■ physical activity ■ prevention ■ risk factor

Meta-analyses have indicated that physical activity protects from stroke approximately to the same degree as from coronary heart disease.1,2 More recently published studies have supported these results.3,4 There is also convincing evidence that higher levels rather than moderate levels of activity are associated with a lower stroke risk.3,5 It has been a matter of debate whether both leisure-time and occupational (including commuting) physical activities are beneficial with respect to stroke risk. According to recent meta-analyses, both forms of physical activity yield protective effects.2 With increasing mechanization, physical work plays a rapidly decreasing role and accordingly, more recent articles have focused on leisure-time physical activity.2

In Western societies, sports represent the most important form of physical activity during leisure time. Older studies had suggested that sports activities in adolescence and young adulthood may prevent later stroke,6,7 but such protective effects were not found in other studies.5,8,9 An independent stroke preventive effect of sports activities during early life would have important implications for primary prevention and health education.

There is sufficient evidence that physical activity protects against both ischemic and hemorrhagic strokes.2 Ischemic stroke is itself a heterogeneous disease, and at present, it is unclear whether physical activity differentially reduces the risk of ischemic stroke etiologies. Because physical activity can reduce atherosclerotic vessel changes,10 it is possible that it particularly reduces the risk of atherothrombotic stroke.

In the present case-control study, we tested the hypothesis that both recent sports activities and sports during young adulthood independently protect against stroke and transient ischemic attack (TIA). Using a broad definition of sports, we focused on sports activities, because both life periods were very comparable regarding this most important form of leisure-time physical activity. Furthermore, we investigated the effects on etiologic stroke subtypes and assessed whether the weekly duration of physical activity and stroke risk were associated.

Subjects and Methods

We investigated 370 consecutive patients who were admitted to the Neurology Department of the University of Heidelberg Hospital between November 2001 and April 2003 for ischemic stroke, TIA, or intracerebral hemorrhage and 370 control subjects randomly selected from the general population. Exclusion criteria for patients was an age >80 years, residence outside the defined study area (city of...
Heidelberg and the neighboring county), and inability to give informed consent due to aphasia, dementia, loss of consciousness, or other reasons. After the first 6 months, the age limit was lowered to 75 years owing to difficulties in finding adequate control subjects for the elderly group. Among 385 eligible patients, representing >65% of hospitalized patients from the study area, 370 (96.1%) agreed to participation in the study. All patients received a cranial computed tomography and/or a cranial magnetic resonance imaging scan, extra- and transtemporal Doppler sonography, an ECG, and in most cases, transthoracic or transesophageal echocardiography and Holter monitoring. Further examinations (eg, lumbar puncture) were performed as indicated clinically. Ischemic stroke was defined as either a central nervous system deficit lasting ≥24 hours without any evidence of a nonvascular cause and cerebral hemorrhage being excluded by neuroimaging, or a new ischemic lesion on neuroimaging that explained the acute neurologic deficit, regardless of whether the symptoms lasted <24 or >24 hours. The diagnosis of intracerebral hemorrhage was based on neuroradiologic evidence. A TIA was diagnosed when a neurologic deficit of vascular origin was completely reversible within 24 hours and no new vascular lesion on neuroimaging was found. Ischemic stroke and TIA were further subtyped according to TOAST criteria.11

From the Inhabitant Registration Authority of our area, we received a list containing the name, age, sex, and address of a random sample of 2% of all inhabitants age 18 to 80 years. Control subjects were randomly selected from this sample and matched to patients 1 to 1 for age (±2 years), sex, and residence in the same community or a community in the vicinity (maximal distance, 10 km). This latter criterion was applied to obtain comparable living conditions, ie, in a rural or urban locality. Within 1 week after a patient was included, the first matching subject who could be identified in the random sample was contacted by mail and thereafter by phone. The same exclusion criteria used for patients were valid for control subjects. With high probability, control subjects would have become patients in our department if they had experienced a stroke. Among 430 subjects who could be contacted by phone, 370 (86.0%) agreed to participation in the study.

All subjects were interviewed in a standardized way by trained interviewers who used a structured questionnaire. The interview was performed face to face for patients and by phone for control subjects. If a patient or control subject was unable to complete the whole interview because of fatigue or for cognitive reasons, the interviewers were instructed to contact a next of kin for completion of the interview. Besides questions on physical activity, the interview was related to vascular risk factors and diseases, chronic infections, smoking, alcohol consumption, medication, education and current profession, marital status, family history, lifestyle factors, and health-related behavior, including previous vaccinations. We asked for any physical handicap that might prevent subjects from participating in sports and quoted “unrestricted mobility” if such handicap was denied. To avoid classification bias, self-reported risk factors and diseases were acknowledged if subjects affirmed that a physician had made the respective diagnosis before the stroke or interview (“Did a physician ever tell you that you have...”). To assess health-related lifestyle, we asked for routine medical and dental check-ups (see Table 1). The ethics committee approved the study protocol. All subjects gave informed consent.

Sport was defined in accordance with the definition of the German Olympic Sports Association as any leisure-time motor activity that had its aim in itself or was performed for no other purpose than to improve or maintain physical fitness. Thus, activities such as walking were included, whereas in this study, physical activity during work, physical activity on the way to or from work, or activities such as gardening were not considered.12 Subjects were asked whether they had regularly performed sports during the months before stroke or interview and if so, how many hours per week they had exercised and which sort of sports were done. Similar questions were related to sports activity between age 20 and 30 years. The weekly duration of sports was stratified as follows: 0, ≤2, >2 but ≤7, and >7 hours per week.

### Statistical Analysis

Dichotomous variables were compared by the χ² test or conditional logistic-regression analysis for matched pairs, as appropriate. For comparison of continuous variables, Student’s t test was applied. Odds ratios (ORs) and 95% CIs are given for different risk factors. Conditional logistic-regression analysis for matched pairs was used to adjust for other variables and included all generally accepted stroke risk factors and associated diseases (hypertension, diabetes...
Table 2. Recent Sports Activities and Risk of Stroke/TIA: Multivariable Analysis*

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>OR</th>
<th>95% CI</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recent sports activities</td>
<td>0.64</td>
<td>0.43–0.96</td>
<td>0.029</td>
</tr>
<tr>
<td>Arterial hypertension</td>
<td>1.85</td>
<td>1.27–2.70</td>
<td>0.0014</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>1.08</td>
<td>0.63–1.85</td>
<td>0.78</td>
</tr>
<tr>
<td>Hyperlipidemia</td>
<td>1.36</td>
<td>0.91–2.02</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Previous stroke/TIA</td>
<td>6.14</td>
<td>3.39–11.1</td>
<td>0.0001</td>
</tr>
<tr>
<td>Coronary heart disease</td>
<td>0.93</td>
<td>0.56–1.54</td>
<td>0.77</td>
</tr>
<tr>
<td>Peripheral arterial disease</td>
<td>1.04</td>
<td>0.60–1.79</td>
<td>0.89</td>
</tr>
<tr>
<td>Alcohol abstinence</td>
<td>1.76</td>
<td>1.07–2.90</td>
<td>0.026</td>
</tr>
<tr>
<td>&gt;1 portion alcohol/day†</td>
<td>2.62</td>
<td>1.16–5.94</td>
<td>0.021</td>
</tr>
<tr>
<td>Current smoking‡</td>
<td>1.62</td>
<td>1.04–2.51</td>
<td>0.031</td>
</tr>
<tr>
<td>Positive family history for stroke</td>
<td>1.78</td>
<td>1.16–2.73</td>
<td>0.0089</td>
</tr>
<tr>
<td>School education ≥10 y</td>
<td>0.83</td>
<td>0.64–1.06</td>
<td>0.13</td>
</tr>
</tbody>
</table>

*Analysis is based on 350 case-control pairs without any missing value. †For definition see Table 1. ‡Reference category—non currently smoking.

More patients than control subjects reported that they had unrestricted mobility before the stroke or interview (P=0.009; Table 1). When unrestricted mobility was included in the model in Table 2, results regarding recent sports activities did not change in a relevant way (OR=0.57; 95% CI 0.37 to 0.87; P=0.0088).

Subgroup Analyses

Among patients, 244 (66.0%) had ischemic stroke, 76 had a TIA (20.5%), and 41 (11.1%) had an intracerebral hemorrhage. In 9 patients (2.4%), etiology could not be firmly differentiated. Recent sports activity was not different between patients with ischemic stroke (54/244, 22.1%), patients with TIA (23/76, 30.3%), and patients with intracerebral hemorrhage (12/41, 29.3%; P=0.27). Recent sports were associated with reduced risk of ischemic stroke (OR=0.36; 95% CI, 0.24 to 0.54) but not with a significantly reduced risk of TIA (OR=0.67; 95% CI, 0.35 to 1.26) or intracerebral hemorrhage (OR=0.69; 95% CI, 0.30 to 1.62). In the multivariable model, sports activities remained associated with reduced odds of ischemic stroke (OR=0.44; 95% CI, 0.27 to 0.69; P<0.001). Sports activity reduced the risk of both first-ever stroke or TIA and recurrent stroke in univariable and multivariable analysis (Table 3).

The proportion of patients with recent sports activities varied between etiologic subgroups of ischemic stroke (large-artery atherosclerosis: 25/130, 19.2%; undefined etiology: 15/72, 20.8%; cardiac embolism: 18/63, 28.6%; cerebral microangiopathy: 9/30, 30.0%; other defined etiologies: 10/25, 40.0%), but these differences did not reach statistical significance (P=0.145). In univariable analysis, sports significantly reduced the odds of ischemia due to large-artery atherosclerosis and undefined etiology. After adjustment for covariates, there was a trend toward a lower risk of stroke/TIA due to large-artery atherosclerosis (Table 3).

Among patients, there was no difference in sports activities regarding age (<60 years/≥60 years), sex, presence of hypertension, diabetes mellitus, previous stroke/TIA, and smoking (data not shown). In the control group, current smokers (23/70, 32.9%) participated in sports less often than did nonsmokers (142/300, 47.3%; P=0.03), and hypertensive subjects (58/151, 38.4%) tended to perform sports less often than did nonhypertensives (107/219, 48.9%; P=0.05). In both the patient and control groups, fewer subjects with less formal education (<10 years) performed sports than did better-educated persons (patients: 58/256, 22.7% vs 40/103, 38.8%, P=0.0019; control subjects: 81/219, 37.0% vs 83/146, 56.9%, P=0.0002). Sports activities reduced the odds of stroke/TIA in subjects <60 years and in men and tended to reduce the risk in older subjects and in women (Table 3).

Recent and Previous Sports Activities

There was no difference between patients (n=175, 48.5%) and control subjects (n=172, 47.1%) regarding regular sports activities between the age of 20 and 30 years (Table 1). Approximately 50% of subjects were unable to recall the number of hours spent on sports activities at that age; therefore, further analyses were impossible. More patients (n=161, 44.6%) than control subjects (n=124, 34.0%) had performed sports neither recently nor in young adulthood (P<0.05). Compared with this group as the baseline category,
Sports activity at a young age only did not alter the odds of stroke or TIA. Sports activities both recently and in young adulthood were associated with reduced odds of stroke/TIA in univariable but not significantly in multivariable analysis. A pattern of no sports activity at age 20 to 30 years but such activities recently was correlated with lower odds of stroke/TIA in both univariable and multivariable analyses (Table 4).

**Discussion**

In this case-control study, we found that recent sports activities are independently associated with a reduced risk of combined stroke and TIA and in particular, with a reduced risk of ischemic stroke. Self-reported sports activity in young adulthood did not protect against stroke. However, more control subjects than patients who were inactive in young adulthood took up sports activities later on, and such a pattern was associated with significantly reduced odds of stroke or TIA.

Meta-analyses and recent large studies have shown that physical activity reduces the risk of both ischemic and hemorrhagic stroke. In our study, a protective effect for intracerebral bleeding could not be detected, probably owing to the small number of subjects with hemorrhagic stroke. To the best of our knowledge, data on the role of physical activity in etiologic subtypes of ischemic stroke have not been available so far. Our results that suggest protection from ischemia due to large-artery atherosclerosis are in accordance with studies that showed improvements in carotid atherosclerosis by physical activity. However, the numbers of subjects in subgroups were low, subgroup analyses lack statistical power, and results have to be viewed with caution.

There are several mechanisms by which physical activity and sports reduce the risk of stroke. Physical activity lowers blood pressure, improves lipid profiles and glucose metabolism, and reduces body weight. Furthermore, physical activity improves endothelial and vasomotor function, reduces fibrinogen levels and blood viscosity, lowers platelet aggregability, stimulates thrombolytic mechanisms, and reduces inflammation. Thus, physical activity exerts protective effects beyond its positive influences on traditional vascular risk factors.

Physical activity comprises a large array of activities, and definitions have varied widely in previous studies. Meta-analyses and recent large studies have shown that occupational and leisure-time physical activity protect against stroke, and even commuting physical activity appears to possess protective properties. For several reasons, we restricted our analysis to sports activity. First, we intended to keep the questions as simple as possible for the interviews with acutely ill patients. Second, sports are nowadays the most important form of leisure-time physical activity, they are almost always

<table>
<thead>
<tr>
<th>Parameter</th>
<th>No. of Patients</th>
<th>Univariable Analysis OR, 95% CI</th>
<th>Multivariable Analysis OR, 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>First-ever stroke/TIA†</td>
<td>301</td>
<td>0.52, 0.37–0.73</td>
<td>0.61, 0.39–0.95</td>
</tr>
<tr>
<td>Recurrent stroke</td>
<td>69</td>
<td>0.29, 0.14–0.61</td>
<td>0.26, 0.10–0.69</td>
</tr>
<tr>
<td>Ischemic stroke</td>
<td>244</td>
<td>0.36, 0.24–0.54</td>
<td>0.44, 0.27–0.69</td>
</tr>
<tr>
<td>TIA</td>
<td>76</td>
<td>0.67, 0.35–1.26</td>
<td>1.09, 0.50–2.38</td>
</tr>
<tr>
<td>Hemorrhagic stroke</td>
<td>41</td>
<td>0.69, 0.30–1.62</td>
<td>0.60, 0.20–1.76</td>
</tr>
</tbody>
</table>

**Table 4. Recent Sports Activity, Sports During Young Adulthood, and Stroke/TIA**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Patients, N or n (%)</th>
<th>Controls, N or n (%)</th>
<th>Univariable Analysis OR, 95% CI</th>
<th>Multivariable Analysis OR, 95% CI*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recent Sports Age 20–30 y</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>+</td>
<td>68 (18.8%)</td>
<td>92 (25.2%)</td>
<td>0.53, 0.35–0.80</td>
<td>0.73, 0.47–1.14</td>
</tr>
<tr>
<td>+</td>
<td>25 (6.9%)</td>
<td>69 (18.9%)</td>
<td>0.25, 0.15–0.42</td>
<td>0.37, 0.21–0.65</td>
</tr>
<tr>
<td>−</td>
<td>107 (29.6%)</td>
<td>80 (21.9%)</td>
<td>0.98, 0.67–1.44</td>
<td>1.22, 0.81–1.85</td>
</tr>
<tr>
<td>−</td>
<td>161 (44.6%)</td>
<td>124 (34.0%)</td>
<td>1.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>

*Model as in Table 3.
performed voluntarily, and they are usually associated with positive emotions, whereas gardening and similar activities are sometimes rather a burden. Third, sports activity in earlier life is well recalled, and comparisons between recent and early-adulthood activity as a focus of this study appeared to be best performed with questions restricted to sports activity. Fourth, occupational physical activity has become less important in recent decades, along with increasing automation. Work-related physical activity differs from sport activities in several aspects; eg, it includes less dynamic and more static movement patterns, and these different features may have a different impact on blood pressure reduction.19 Sports activity is directly associated whereas physical activity during work is inversely associated with socioeconomic status; therefore, social status may be an important confounding factor. School education was part of our multivariable analysis to adjust at least partly for such influences. On the other hand, commuting physical activity such as cycling may also be associated with reduced stroke risk, and it is possible that the effect by physical activity has been underestimated here by excluding commuting physical activity.

Some previous studies showed a dose-response relation, with longer-lasting or more vigorous exercise being associated with lower hazards of stroke,5,20,21 whereas the Framingham Study22 and other studies7,23 reported that beyond a moderate level of physical activity, no further risk reduction could be detected. Our study showed a reduced risk of stroke with increasing hours of exercise; however, this association was not statistically significant in multivariable analysis. Because of the low numbers of subjects who engaged in long-lasting sports activity, it is unclear whether a ceiling effect in fact exists. Furthermore, a limitation of our study is that the intensity of the sport activities could not be quantified.

The Harvard Alumni study had shown that participation in a university sports program was associated with a reduced risk for lethal stroke 10 to 50 years later, although an adjustment for potential confounding factors was not performed and the same result was not found for nonlethal stroke in a later analysis.6,24 In a case-control study, engaging in sports between the ages of 15 and 25 years independently reduced stroke risk, as did recent sports activity.7 In contrast, in a study of Swedish women, physical activity in the previous year but not between the ages of 20 and 38 or after the age of 38 reduced stroke risk.9 Similarily, the Reykjavik Study found that physical activity between ages 20 and 30 did not protect against stroke, whereas physical activity after age 40 independently reduced stroke risk.8 In keeping with the 2 last-cited studies, our results do not indicate a protective effect by sports activity during early adulthood. Habits regarding sports activities change over time. Interestingly, fewer patients than control subjects became active sportspersons in later life after having been passive in early adulthood, whereas more patients than control subjects who were active at a young age quit sports later. Starting sports activities at a later age was associated with highly reduced odds of stroke/TIA in our study. This underscores that both groups differed particularly in attitudes that were adopted during later adulthood. However, we cannot exclude that comorbidities that precluded exercise and that were not included in our analyses contributed to such results.

Among the strengths of this study are the consecutive patient recruitment and the high participation rate among eligible patients and control subjects, a fact that reduces the likelihood of selection bias. However, there are also some limitations to our study. The study was performed in a university hospital in which younger patients are overrepresented and some stroke etiologies (eg, large-artery atherosclerosis) are more common than would be expected in a population-based study. Thus, our patient sample may be representative only of patients up to the age of 75. Patients with very severe strokes (≈35% of all patients) who could not be interviewed had to be excluded; thus, the study results cannot be generalized to patients with severe stroke. Patients were interviewed face to face and control subjects were interviewed by phone; this represents a potential source of bias. People more often tend to give answers that appear to be socially desirable, and such a “social desirability bias” may be more pronounced in face-to-face interviews. It is also possible that control subjects with physical handicaps were overrepresented in our control group because the interviews were conducted by phone. However, these influences would tend to weaken the association between sports and stroke risk. We had to rely on subjects’ self-report, thus raising the possibility of a misclassification bias due to overestimation of the amount of sports activity performed. Distant events are often not precisely recalled, also raising the possibility of recall bias, particularly for sports in early adulthood. In fact, the duration of sports at that time was not recalled well enough; therefore, these data could not be used in this study. However, participation in sports or not at that age was remembered with sufficient precision. In multivariable analysis, multiple potential confounding factors were considered, and recent sports remained significant after adjustment for these covariates. Residual confounding (eg, by diet or medication) still cannot be excluded. However, our main result is in accordance with findings from prospective cohort studies, strengthening the confidence with our study results.

In conclusion, our study supports previous results showing stroke protection by physical activity. Continuous lifetime sports activity or starting such activities during later adulthood appears to be required to reduce stroke risk, whereas sport activity solely during young adulthood appears to be insufficient.

Disclosures
Armin J. Grau received speaker honoraria from Boehringer Ingelheim, Sanofi-Aventis and Bristol-Meyer-Squibb and unrestricted research grants from Boehringer Ingelheim and Sanofi-Aventis. Christoph Lichy received speaker honoraria from Boehringer Ingelheim, Sanofi-Aventis, and Shire.

References


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