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Lipid, Lipoprotein, and Apolipoprotein Profiles in Active and Sedentary Men With Tetraplegia

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Objective: To investigate whether the risk profile of coronary heart disease (CHD) is more favorable in physically active men with tetraplegia compared with sedentary men with tetraplegia.

Design: Using a cross-sectional design, the lipid and (apo)lipoprotein concentrations of 11 active and 13 sedentary men with tetraplegia were compared. Regression analysis was applied to investigate the influence of subject characteristics and behavioral factors on the risk profile of CHD.

Main Outcome Measures: Total plasma cholesterol (TC), high-density lipoprotein cholesterol (HDL-C), triglycerides, apolipoprotein-A1 (ApoA1), and apolipoprotein-B (ApoB) concentrations were determined. Low-density lipoprotein cholesterol (LDL-C) and the ratios TC/HDL-C, LDL-C/HDL-C, ApoA1/ApoB, and HDL-C/ApoA1 were calculated.

Results: A significantly higher HDL-C and ApoA1/ApoB and lower TC/HDL-C were found in the active group. Age and body mass index were important determinants of the lipids and (apo)lipoproteins. Sport activity was the only significant determinant of HDL-C.

Conclusions: Results suggest a positive influence of sport activity on HDL-C in men with tetraplegia, which may reduce the risk of CHD.

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METHODS

Subjects and Procedure

Twenty-four men with tetraplegia, with lesion levels ranging from C5 to C8, participated in this study, after having given their written informed consent. Subjects were divided into an active group (ACT, n = 11), including subjects who were active in regular sport activities for at least 6 months, and a sedentary group (SED, n = 13). In ACT, 4 subjects had an incomplete lesion (ASIA Impairment ScaleD: D [n = 3] and C [n = 1]), whereas all subjects in SED had a complete lesion. Figure 1 shows the number of subjects per lesion level for each group.

All subjects were participants in a separate study evaluating effects of sport activity on performance capacity. Only subjects without symptoms of cardiovascular diseases or other medical complications were included in the study. Subjects were all living independently and could propel a hand-rim wheelchair.

Blood samples were collected in the morning or early afternoon. Subjects were asked to eat a low-fat breakfast only (bread and tea) at least 2 hours before blood samples were taken. Sports activity was defined as hours of sports participation per week, and ranged in ACT from 1.5 to 6.0 hours per week. All subjects of ACT participated in a weekly quad rugby training (1.5h/wk). Additional sports activities were wheelchair dancing (n = 1), wheelchair basketball (n = 1), and table tennis (n = 1). Smoking behavior was defined as the number of cigarettes smoked per day. Only 4 subjects were smokers (2 in ACT and 2 in SED), and they smoked 2 to 15 cigarettes per day. Alcohol consumption, defined as units alcoholic beverages per week, ranged from 0 (n = 7) to 30 glasses per week. Eight
subjects (3 in ACT and 5 in SED) had a history of CHD in parents, brothers and/or sisters. Body mass was determined on a hospital scale. Body mass index (BMI [kg/m²]) was defined as body mass divided by the square of self-reported height. Peak oxygen uptake (VO₂peak [mL/kg/min]) was determined as a measure of physical fitness in a separate maximal wheelchair exercise test. Subject characteristics and behavioral factors are summarized in table 1.

Blood Lipids and (Apo)Lipoproteins

Blood samples were drawn by venal puncture into K3EDTA-containing vacutainer tubes. Plasma was isolated within 3 hours for determination of the lipid, lipoprotein, and apolipoprotein levels, and was stored at −80°C until analysis. TC and triglyceride (TG) concentrations were determined by enzymatic, commercially available reagents.® HDL-C was determined by the polyethylene glycol 6000 method.® Low-density lipoprotein cholesterol (LDL-C) concentration was calculated by the Friedewald formula.® Total plasma apoA1 and apoB were determined by immunephelometry.® To achieve accurate results in relation to the Centers for Disease Control standardization program, the obtained values were recalculated on the basis of an exchange of sera with Dr. S. Marcovina of the Northwest Lipid Research Laboratory, Seattle WA. The ratios TC/HDL-C, LDL-C/HDL-C, ApoA1/ApoB, and HDL-C/ApoA1 were calculated because these parameters are considered to be relevant indicators of an increased risk of CHD.®

Statistics

A Student’s t test for independent samples was applied to detect differences between groups for subject characteristics, behavioral factors, and the lipids and (apo)lipoproteins. To investigate the influence of subject characteristics and behavioral factors on the lipids and (apo)lipoproteins, stepwise multiple regression analysis was applied, using as independent variables age, lesion level, completeness of the lesion (complete lesion = 1, incomplete lesion = 0), time since injury, body mass, BMI, sport activity (sport participation = 1, no sport participation = 0), smoking behavior, alcohol consumption, VO₂ peak and family history of CHD (with family history of CHD = 1, without family history of CHD = 0). Results were considered significant at p ≤ .05.

To determine whether active men with tetraplegia are at increased risk of CHD, the results were qualitatively compared with data from the able-bodied population.®

RESULTS

Subjects

There were no significant differences between groups in age, time since injury, body height, smoking behavior, and alcohol consumption. Body mass and BMI were significantly lower, and VO₂ peak was significantly higher, in ACT compared with SED (table 1).

Blood Lipids and (Apo)Lipoproteins

Table 2 summarizes the lipid and (apo)lipoprotein concentrations for both groups. ACT showed a significantly higher value for HDL-C and ApoA1/ApoB, and a lower ratio TC/HDL-C, compared with SED (p ≤ .05). No significant differences were found between groups for TC, LDL-C, LDL-C/HDL-C, TG, ApoA1, ApoB, and HDL-C/ApoA1.

Results of the regression analysis, investigating the influence of subject characteristics and behavioral factors (including sport activity) on the lipids and (apo)lipoproteins, are listed in table 3. BMI was the only significant determinant of TC/HDL-C, LDL-C/HDL-C, and HDL-C/ApoA1, explaining 24%, 18%, and 19% of the variance, respectively. These results show that no differences in TC/HDL-C between ACT and SED are found when results are adjusted for BMI. Age was the most important determinant of TC, TG, ApoA1/ApoB, and TC/HDL-C. ApoA1/ApoB this implies that, although a difference was found between ACT and SED, age is a more important determinant than sport activity. Sport activity was the only significant determinant of HDL-C, explaining 17% of the variance, irrespective of the other independent variables (including BMI, age, and lesion level). No significant relationships were found for lesion level,
From table 3 it appears that for ApoAl, ApoB, and ApoAl/ApoB, adjusted for age (and completeness of the lesion in body mass, family history for CHD, V02 peak, smoking behavior, alcohol consumption, and sport activity on the lipids and (apo)lipoproteins (n = 24)).

Comparing the results of ACT with data from the able-bodied population (TC, 4.7mmol/L; and LDL-C, 1.15mmol/L for men aged 25 to 29yrs$^{25}$; LDL-C, 3.2mmol/L for men aged 30 to 39yrs$^{13}$; TG, 1.26mmol/L for men aged 20 to 34yrs$^{2}$) revealed normal concentrations for TC, LDL-C, HDL-C, and TG (table 2). The ApoAl concentration was considerably lower and ApoB was (slightly) higher in ACT, compared with able-bodied subjects (ApoAl, 1.35g/L; ApoB, .92g/L for men aged 30 to 39yrs$^{13}$; TG, 1.26mmol/L for men aged 20 to 34yrs$^{2}$).

Table 3: Results of Multiple Regression Analysis

<table>
<thead>
<tr>
<th>Variables</th>
<th>Regression Coefficients ± Standard Error</th>
<th>Independent Variables</th>
<th>p Value</th>
<th>r²</th>
</tr>
</thead>
<tbody>
<tr>
<td>TC (mmol/L)</td>
<td>0.053 ± 0.020 Age</td>
<td>.014 .24</td>
<td></td>
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<tr>
<td>3.044 ± 0.888</td>
<td>.000</td>
<td></td>
<td></td>
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<tr>
<td>HDL-C (mmol/L)</td>
<td>−1.74 ± 0.888 Sport activity</td>
<td>.048 .17</td>
<td></td>
<td></td>
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<tr>
<td>0.952 ± 0.056</td>
<td>.000</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>LDL-C (mmol/L)</td>
<td>—</td>
<td>—</td>
<td></td>
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</tr>
<tr>
<td>TCHDL-C</td>
<td>−0.01 ± 0.047 BMI</td>
<td>—</td>
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<tr>
<td>1.09 ± 1.126</td>
<td>.104</td>
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<tr>
<td>LDL-C/HDL-C</td>
<td>0.84 ± 0.039 BMI</td>
<td>0.40 .18</td>
<td></td>
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<tr>
<td>1.07 ± 0.926</td>
<td>.260</td>
<td></td>
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<tr>
<td>TG (mmol/L)</td>
<td>0.07 ± 0.015 Age</td>
<td>.000 .34</td>
<td></td>
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<tr>
<td>−0.02 ± 0.026 Time since Injury</td>
<td>.008 .53</td>
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<tr>
<td>−0.347 ± 0.474</td>
<td>.472</td>
<td></td>
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<tr>
<td>ApoA1 (g/L)</td>
<td>−0.01 ± 0.065 Completeness</td>
<td>.011 .20</td>
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<tr>
<td>0.005 ± 0.002 Age</td>
<td>.043 .34</td>
<td></td>
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<tr>
<td>1.00 ± 0.090</td>
<td>.000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ApoB (g/L)</td>
<td>0.01 ± 0.005 Age</td>
<td>.002 .35</td>
<td></td>
<td></td>
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<tr>
<td>0.55 ± 0.176</td>
<td>.005</td>
<td></td>
<td></td>
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<tr>
<td>ApoA1/ApoB</td>
<td>−0.01 ± 0.004 Age</td>
<td>.021 .22</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.40 ± 0.163</td>
<td>.000</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>HDL-C/ApoA1</td>
<td>−0.004 ± 0.002 BMI</td>
<td>.033 .19</td>
<td></td>
<td></td>
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<tr>
<td>0.45 ± 0.042</td>
<td>.000</td>
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</table>

Multiple regression analysis investigated the influence of age, level and completeness of the lesion, time since injury, body mass, BMI, V02 peak, family history for CHD, smoking behavior, alcohol consumption, and sport activity on the lipids and (apo)lipoproteins. The results indicate that sports activity was the only significant determinant of HDL-C. The higher HDL-C for ACT in the present study is in agreement with previous cross-sectional studies, in which sedentary subjects and wheelchair athletes with SCI were compared.$^{4,5}$ Longitudinal research is required to establish causal relationships between training and risk factors of CHD in persons with tetraplegia. The absence of a relation between smoking and the lipids and (apo)lipoproteins in the present study is probably the result of the low number of smokers. The significantly higher V02 peak in ACT might be explained by the higher training status of this group, although the 4 subjects with incomplete lesions in ACT can also account for the higher V02 peak, due to a larger available muscle mass. This may also explain the nonrelation between V02 peak as a measure of physical fitness, and the lipids and (apo)lipoproteins. The results of the present study were comparable to results for persons with paraplegia,$^{4,5}$ which indicates that lesion level is not affecting the lipid and (apo)lipoprotein profiles. The assumption that persons with tetraplegia are at higher risk of CHD than persons with paraplegia cannot be confirmed by the present study.

Qualitative comparison with data from the able-bodied population revealed that active men with tetraplegia showed normal levels of HDL-C, whereas for the sedentary subjects lower concentrations were observed. These results suggest that being physically active can increase HDL-C and thus decrease the risk of CHD in men with tetraplegia. Several studies showed depressed levels of HDL-C in persons with SCI,$^{4,5,16}$ whereas in another study no differences could be found between able-bodied and subjects with SCI.$^{20}$ Differences in activity level might therefore be responsible for these contradictory results. In contrast to the normal value for HDL-C in ACT, results showed depressed ApoA1 and elevated ApoB levels for ACT, in comparison with the able-bodied population. Consequently, a depressed ratio ApoA1/ApoB was observed, compared with able bodied subjects.$^{27}$ Since ApoA1 concentrations of <1.20g/L are associated with an increased risk of CHD,$^{28}$ the low values for ApoA1 in the present study show that (active) men with tetraplegia have an increased risk of CHD. Furthermore, an increased ApoB level in combination with a normal LDL-C is also associated with a higher risk of CHD, because of an increase of small, dense LDL particles, which contain less cholesterol than normal LDL.$^{11}$

The results of this study suggest a positive influence of sport activity on HDL-C in men with tetraplegia, which may reduce the risk of CHD. Based on the depressed levels of ApoA1, and an increased level of ApoB, in combination with a normal LDL-C, both active and sedentary men with tetraplegia are at increased risk of CHD.

CONCLUSIONS

The results of this study suggest a positive influence of sport activity on HDL-C in men with tetraplegia, which may reduce the risk of CHD. Based on the depressed levels of ApoA1, and an increased level of ApoB, in combination with a normal LDL-C, both active and sedentary men with tetraplegia are at increased risk of CHD.

Acknowledgment: We thank Dr. P.N.M. Demaeker, Lab of General Internal Medicine, University Hospital Nijmegen, for his comments and for measurements of the lipids, lipoproteins, and apoproteins.

Arch Phys Med Rehabil Vol 78, November 1997
References


Suppliers

a. Catalogue no. 237574; Boehringer Mannheim GmbH, Santhoferstrasse 116, Mannheim 68298, Germany.

b. Catalogue no. 6639, Sara Pak; Miles, Viale Certosa 210, Milano 20156, Italy.