Validity and Reliability of the Huet Questionnaire to Assess Maximal Oxygen Uptake

Damien Trivel¹, Paul Calmels¹, Luc Léger², Thierry Busso¹, Xavier Devillard¹, Josiane Castells¹, and Christian Denis¹

Catalogue Data

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Mots-clés: activité physique, épidémiologie, évaluation

Abstract/Résumé
The usual fitness tests available to assess maximal oxygen uptake (VO₂max), a key fitness component, are not particularly useful for epidemiological studies. Questionnaires to assess VO₂max, however, are simple, easy to use, and inexpensive. In 1986, Huet developed such a French general questionnaire, which now also has an English version. Its simplicity is interesting as it could be used to survey large populations. The purpose of this study was to assess the validity and reliability of this Huet questionnaire in a sample of healthy French volunteers. A total of 108 subjects were included in this study, 88 males and 20 females. The validity of the questionnaire was checked using correlation coefficients and a Bland-Altman plot between questionnaire estimations and measures of VO₂max obtained with a stress test on a cycle ergometer. An intraclass correlation coefficient (ICC) was also calculated to determine the reliability of the questionnaire. Significant correlation was obtained with the Huet questionnaire and measured VO₂max (r² = 0.77, p = 0.0001, SEE = 5.97 ml·kg⁻¹·min⁻¹, n = 108). The ICC showed very high reliability (ICC = 0.988, n = 21). The Huet questionnaire is an easy, rapidly administered tool that correlated highly with VO₂max in this sample population.

¹Unité PPEH–GIP E2S EA 3062, Faculté de Médecine, Université Jean Monnet, Saint-Etienne cedex 2, France; ²Département de Kinésiologie, Université de Montréal, C.P. 6128, succursale Centre-ville, Montreal, PQ, H3C 3J7.
Les mesures de la consommation maximale d’oxygène (VO₂ max) en laboratoire sont précises mais sont sujettes à des difficultés d’ordre méthodologiques (matérielles, techniques, financières) insurmontables pour des études épidémiologiques. Les questionnaires sont simples, rapides, d’un faible coût, et applicables aux études à grande échelle. Le questionnaire construit par Huet en 1986 possède ces caractéristiques. L’objectif de cette étude est donc d’évaluer la validité et la reproductibilité de cet outil dans un échantillon de sujets volontaires Français. Au total, 108 sujets (88 hommes et 20 femmes) ont fait parti de cette étude. La validité du questionnaire a été étudiée par le calcul du coefficient de corrélation et un test Bland-Altman, entre les VO₂ max mesurés en laboratoire sur cyclo-ergomètre et les estimations obtenues par questionnaire. La reproductibilité a été calculée par le coefficient de corrélation intra-classe. Une corrélation significative a été obtenue pour le calcul de la validité (r² = 0.77, p = 0.0001, SEE = 5.97 ml·kg⁻¹·min⁻¹, n = 108). Le calcul de la reproductibilité n’a pas montré de différence significative entre les deux passations du questionnaire (ICC = 0.988, n = 21). Le questionnaire de Huet est un outil intéressant. Ses caractéristiques et les résultats obtenus avec cette population sont prometteurs (rapidité, facilité, validité, et reproductibilité).

Introduction

Adequate assessment of physical fitness, an important element of overall health status (Blair et al., 1989), is a key issue in epidemiological studies and requires a practical methodology yielding valid results. Exercise tests are useless in that respect whereas questionnaires have always been a tool of choice in epidemiological studies. However, most questionnaires assess physical activity (PA) or energy expenditure (EE) levels, and only a few estimate fitness (VO₂ max) (Kesaniemi et al., 2001). Nevertheless, questionnaires originally developed to assess exercise-based data and the levels of EE have been used as indirect indicators of physical fitness or, more specifically, VO₂ max (George et al., 1997; Jacobs et al., 1993).

VO₂ max is widely accepted as the most valid and reliable index of cardiorespiratory fitness (CRF), itself inversely related to all-cause mortality (Blair et al., 1989). However, these questionnaires have often yielded low correlation (0.01 to 0.45) with VO₂ max (Andersen et al., 1984; Blair et al., 1985; Bouchard et al., 1983; De Backer et al., 1981; Godin and Shephard, 1985; Skinner et al., 1966; Sobolski et al., 1988; Taylor et al., 1978). Thus other questionnaires, specifically developed to predict VO₂ max (often called non-exercise (N-EX) regression model), seem to yield better correlation (0.60 to 0.90) with VO₂ max (Bruce et al., 1973; George et al., 1997; Heil et al., 1995; Jackson et al., 1990; Kolkhorst and Dolgener, 1994; Morrison et al., 1984; Whaley et al., 1995).

These N-EX VO₂ max prediction questionnaires are generally based on a list of 7 to 10 statements describing increasing status of physical activity pattern. Other N-EX predictors such as skinfolds or body max index (BMI), age, gender, and resting heart rate are often added to the regression models.

Interestingly, the accuracy of these N-EX regression models has been quite comparable (R = 0.86, SEE = 3.34) with some exercise (EX) regression models, mostly submaximal tests (R = 0.70–0.91, SEE = 4.84–5.38), but not the best maximal EX regression models (R = 0.93–0.94, SEE = 2.28–3.13) (George et al., 1997). However, the model proposed by George et al. (1997) is in fact a pseudo exercise
approach asking questions such as the time needed for a 1- and a 3-mile run in addition to the items in the PA questionnaire used by Jackson et al. (1990). It is assumed that the subjects walk or run these distances often enough to express knowledge of their experience with them. This is not a very realistic assumption, especially when surveying large groups of sedentary and older people.

George et al. (1997) advocate the 1- and 3-mile run time in addition to the classical PA questionnaire, gender, and BMI because it is known that questionnaires limited solely to these predictors (Ainsworth et al., 1992; Bruce et al., 1973; Heil et al., 1995; Jackson et al., 1990) yield lower correlations ($R = 0.81–0.88$, $SEE = 4.46–5.35$) and do not appear valid enough compared to the best indirect exercise tests. Most models use the PA questionnaire developed by Jackson et al. (1990), but the cross-validation of Jackson’s equations with college students demonstrated rather invalid correlations ($R = 0.24$, $SEE = 5.04$) yielding large systematic underestimations of about 10 ml·kg$^{-1}$·min$^{-1}$ (Kolkhorst and Dolgener, 1994).

In French there are only two known N-EX questionnaires for estimating $\dot{V}O_2_{\max}$ (Boisvert et al., 1988; Vuillemin et al., 1998). The Saint-Etienne Physical Activity Questionnaire (QAPSE: Questionnaire d’Activité Physique de Saint-Etienne) is the only one that estimates the main habitual daily energy expenditure (MHDEE). A strong relationship between MHDEE and $\dot{V}O_2_{\max}$ ($R = 0.92$, $n = 120$, $p < 0.0001$) was found (Berthouze et al., 1995).

In 1986 Huet developed a simple and general questionnaire to assess $\dot{V}O_2_{\max}$ (Montreal University, unpublished, 1986). This questionnaire was later translated in English by Léger (see Appendix). Like different N-EX regression models, it takes into account variables known to be important in predicting $\dot{V}O_2_{\max}$, but also more generally, leisure-time physical activity and occupational physical activity. Its simplicity makes it useful for surveying large populations. Boisvert et al. (1988) described it and reported different preliminary studies. Significant correlations have been observed between the questionnaire items and $\dot{V}O_2_{\max}$ measured on a treadmill run test in spite of 5% underestimation (Léger et al., 1986). Nevertheless, the sample population was not large enough to conclusively assess the validity of this questionnaire. As suggested by Boisvert (1988), further study on a larger population would be required to determine its reliability and validity. Thus the purpose of the present study was to assess the validity and reliability of the French version of the Huet questionnaire in a sample of 108 subjects ages 15 to 69 years. We also ran our own multiple regression analysis using the Huet questionnaire components and BMI to predict $\dot{V}O_2_{\max}$.

**Methods**

**SUBJECTS AND TEST**

A total of 108 healthy male ($n = 88$) and female ($n = 20$) volunteers ages 15 to 69 years, with variable levels of habitual physical activity, were recruited among persons participating in a clinical exercise examination to determine their individual physiological potential for sports or occupational activities. The examination included a maximal multistage test on a leg cycle ergometer with $\dot{V}O_2_{\max}$ measurement performed under medical prescription, independent of the procedure for validating the questionnaire. One of the authors explained the questionnaire to the
subjects. The fact that subjects returned the questionnaire by mail was taken as informed written consent. A subgroup of 21 subjects (9 F and 12 M, ages 20–69) also completed the questionnaire twice within a 6-week period in order to assess its reliability.

The Huet questionnaire contains 10 items and is self-administered. It explores the type, duration, intensity, frequency of participation, physical activities between the ages of 10 and 16 years, and experiences at the competitive level. Other questions concern the subject’s physical aptitudes required by employment, smoking habits, overweight, and disease states. The questionnaire is simple and can be rapidly completed and decoded within 5 minutes.

The answers to the questions were weighted according to their importance, with a positive score for variables associated with high \( \text{VO}_2\text{max} \) (Questions 1, 2, 3, 4, 5, 6, 9) and a negative score conversely (Questions 7, 8, 10). The sum of the first 8 questions (designated X1) was distinguished from the sum of Questions 9 and 10 (designated X2). \( \text{VO}_2\text{max} \) was predicted according to the equation \( \text{VO}_2\text{max} = a + bx1 + x2 \). The terms a and b refer to the age and gender of the subject. Two equations were used in this study to estimate \( \text{VO}_2\text{max} \) in ml·kg\(^{-1}\)·min\(^{-1}\). For males: \( Y = 45.334 - (0.322 \times \text{age}) + (1.729 - 0.018 \times \text{age}) \times X1 + X2 \). For females: \( Y = 37.145 - (0.316 \times \text{age}) + (0.951 - 0.004 \times \text{age}) \times X1 + X2 \) (age expressed in years). These equations for estimating \( \text{VO}_2\text{max} \) from the questionnaire were empirically developed for the general population by deduction from a person having good experience in testing and counseling individuals. No statistical regression was used, and constants in the equations were solely adjusted by trials and errors comparing predicted scores with measured \( \text{VO}_2\text{max} \) values.

Although not very orthodox, the questionnaire grew in popularity and its validity was then checked against direct \( \text{VO}_2\text{max} \) (Léger et al., 1986) and proved to be acceptable (\( R = 0.73, \text{SEE} = 9.2\%, n = 125 \)). We also tried to develop our own prediction equation with multiple regression analysis using X1 and X2 as defined above as well as individual answers to the questions and BMI.

\( \text{VO}_2\text{max} \) was measured by a progressive stress test on a Monark cycle ergometer. Metabolic \( \text{CO}_2 \) production (\( \text{VCO}_2 \)) and \( \text{O}_2 \) uptake (\( \text{VO}_2 \)) were determined using a cardiopulmonary exercise test system (MedGraphics\textsuperscript{TM}, CPX/D, St. Louis, MO) on a breath-by-breath basis. After a warm-up, workload was increased until volitional exhaustion while using a 30-s sampling period. ECG was continuously monitored. Blood lactate concentration was also measured using the YSI 2300 apparatus (Yellow Springs, OH) from blood samples collected at the fingertip 3 minutes after the end of exercise. Three of the following four criteria had to be met to ensure that \( \text{VO}_2\text{max} \) was attained: (a) heart rate within 10% of predicted maximal heart rate; (b) increase in \( \text{O}_2 \) uptake between the highest and the preceding workload not exceeding 150 ml/min; (c) respiratory exchange ratio greater than 1.1; and (d) blood lactate concentration higher than 9 mM.

**STATISTICAL METHOD**

Means and standard deviations of descriptive data (age, weight, and measured and estimated \( \text{VO}_2\text{max} \)) were calculated for the entire sample and by gender and age subgroups. The validity of the questionnaire was assessed by comparing measured
and predicted \( \text{VO}_2 \text{max} \) using correlation and regression analyses. Furthermore, in order to provide a measure of reliability and/or behavioral stability (McDowell and Newell, 1987), a subgroup of 21 subjects completed the questionnaire twice within a 6-week interval. An intraclass correlation coefficient (ICC) was calculated to determine the reliability of the questionnaire.

**Results**

Validation of the Huet questionnaire was performed with a healthy sample of 88 males and 20 females who were 15 to 69 years of age. Mean \( \text{VO}_2 \text{max} \) for the whole population was relatively high: \( 50.4 \pm 14.3 \text{ ml·kg}^{-1} \cdot \text{min}^{-1} \), with a mean maximal workload of \( 262.2 \pm 83.8 \text{ W} \). Sixty of the subjects were between 15 and 29 years of age while 12 showed high-level performance in cycling (measured \( \text{VO}_2 \text{max} \): \( 60.6 \text{ ml·kg}^{-1} \cdot \text{min}^{-1} \) at \( 332.5 \text{ W} \)). Finally, 88 subjects (81%) of the studied sample were men. Age, weight, height, and measured and predicted \( \text{VO}_2 \text{max} \) are presented by gender (Table 1) and age (Table 2).

<table>
<thead>
<tr>
<th>Variables</th>
<th>Overall (( N = 108 ))</th>
<th>Males (( n = 88 ))</th>
<th>Females (( n = 20 ))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yrs)</td>
<td>32.4 ± 14.9</td>
<td>30.8 ± 14.1</td>
<td>39.1 ± 16.9</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>67.9 ± 11.6</td>
<td>70.4 ± 10.3</td>
<td>57.0 ± 10.6</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>174.2 ± 9.2</td>
<td>177.2 ± 6.9</td>
<td>161.0 ± 6.5</td>
</tr>
<tr>
<td>( \text{VO}_2 \text{max} ) (ml·kg(^{-1})·min(^{-1}))</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Measured</td>
<td>50.4 ± 14.3</td>
<td>53.8 ± 13.1</td>
<td>35.7 ± 9.5</td>
</tr>
<tr>
<td>Estimated</td>
<td>48.5 ± 12.4</td>
<td>52.0 ± 10.1</td>
<td>33.1 ± 9.1</td>
</tr>
<tr>
<td>Maximal workload (W)</td>
<td>262.2 ± 83.7</td>
<td>286.0 ± 69.2</td>
<td>154.1 ± 55.9</td>
</tr>
</tbody>
</table>

**VALIDITY AND RELIABILITY**

Significant correlation between measured and predicted \( \text{VO}_2 \text{max} \) was obtained using the two equations, one for females and one for males (\( R = 0.88, \text{SEE} = 6.85, n = 108, \) Figure 1 and Table 3). Almost similar correlation was obtained using some of the Huet questions and BMI without age and gender (\( R = 0.85, \text{SEE} = 7.54, n = 108, \) Figure 2 and Table 3). Good correlations were also obtained for each gender and age group, except the older one (Table 3). The ICC showed very high reliability (\( \text{ICC} = 0.988, n = 21 \)).
Table 2  Subjects’ Physical Characteristics (mean ± SD) and Physiological Values by Age Groups

<table>
<thead>
<tr>
<th>Variables</th>
<th>15–19 yr (n=22)</th>
<th>20–29 yr (n=39)</th>
<th>30–39 yr (n=15)</th>
<th>40–49 yr (n=13)</th>
<th>50–59 yr (n=13)</th>
<th>60–69 yr (n=6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yrs)</td>
<td>17.4 ±1.3</td>
<td>22.4 ±3.2</td>
<td>34.3 ±2.9</td>
<td>45.6 ±2.8</td>
<td>54.3 ±3.5</td>
<td>64.3 ±3.4</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>62.1 ±8.0</td>
<td>69.3 ±1.4</td>
<td>68.4 ±9.2</td>
<td>73.4 ±16.1</td>
<td>68.5 ±11.1</td>
<td>66.4 ±14.9</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>174.1 ±8.5</td>
<td>178.3 ±8.5</td>
<td>175.2 ±7.5</td>
<td>171.7 ±10.1</td>
<td>166.9 ±6.3</td>
<td>166.7 ±10.8</td>
</tr>
<tr>
<td>( \dot{V}O_2 \text{ max} ) (ml·kg(^{-1})·min(^{-1}))</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Measured</td>
<td>61.5 ±7.3</td>
<td>56.3 ±13.2</td>
<td>47.8 ±13.3</td>
<td>38.3 ±9.0</td>
<td>35.5 ±7.3</td>
<td>36.8 ±2.6</td>
</tr>
<tr>
<td>Estimated</td>
<td>60.1 ±6.3</td>
<td>53.7 ±8.9</td>
<td>48.0 ±8.0</td>
<td>38.0 ±7.0</td>
<td>33.3 ±7.3</td>
<td>29.8 ±4.6</td>
</tr>
<tr>
<td>Max workload (W)</td>
<td>321.1 ±50.8</td>
<td>303.5 ±71.2</td>
<td>240.9 ±87.5</td>
<td>200.0 ±52.9</td>
<td>181.5 ±41.2</td>
<td>170.0 ±41.5</td>
</tr>
</tbody>
</table>

Discussion

Results of this study support the validity and the reliability of Huet’s questionnaire. In the original study, Léger et al. (1986) obtained similar results for running-trained subjects \((R = 0.73, \text{SEE} = 9.2\% , n = 125)\) and for sedentary subjects \((R = 0.80–0.87, \text{SEE} = 9.8–15\% , n = 22–24)\). The English version of the questionnaire also yielded a similar correlation \((R = 0.83, p < 0.05, n = 88)\) (Boisvert et al., 1988). Furthermore, these results confirm previous ones but also prove the robustness or external validity of this questionnaire for European subjects, as was demonstrated in a Canadian population in previous studies (Boisvert et al., 1988; Léger et al., 1986).

The descriptive data of the study sample show that subjects were predominantly young, male, and athletic, and that the various age groups had inconsistent numbers of subjects. Even though VO\(_2\)max values are quite comparable to those reported in the literature for a young male population, with values in the 45 to 50 ml·kg\(^{-1}\)·min\(^{-1}\) range (Lacour, 1992), this sample is not completely representative of many large survey populations. Thus VO\(_2\)max values obtained with the Huet questionnaire were not only well correlated to direct measures but also quite realistic. However, the lack of a sufficient number of female subjects ages 40 to 60 and subjects ages 60 to 69 in our sample makes it difficult to be confident that the Huet would be valid for these populations. The validity and reliability of this questionnaire should thus be established across a variety of large samples and then by formulating more specific questions for these subpopulations.
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Figure 1. Regression analysis between measured and estimated VO$_2$ max using the Huet questionnaire. Subgroup curves are given only if enough data. Dotted line is the whole group regression (N = 108).

Table 3  Correlations Coefficients Between Measured and Estimated VO$_2$max With Huet Questionnaire by Gender and Age Groups

<table>
<thead>
<tr>
<th>Population</th>
<th>Huet Questionnaire</th>
<th>Q1,Q3,Q9, &amp; BMI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>r</td>
</tr>
<tr>
<td>Overall</td>
<td>108</td>
<td>0.88</td>
</tr>
<tr>
<td>Females</td>
<td>20</td>
<td>0.85</td>
</tr>
<tr>
<td>Males</td>
<td>88</td>
<td>0.84</td>
</tr>
<tr>
<td>15–19 yrs</td>
<td>22</td>
<td>0.77</td>
</tr>
<tr>
<td>20–29 yrs</td>
<td>39</td>
<td>0.80</td>
</tr>
<tr>
<td>30–39 yrs</td>
<td>15</td>
<td>0.83</td>
</tr>
<tr>
<td>40–49 yrs</td>
<td>13</td>
<td>0.77</td>
</tr>
<tr>
<td>50–59 yrs</td>
<td>13</td>
<td>0.80</td>
</tr>
<tr>
<td>60–69 yrs</td>
<td>6</td>
<td>n.s.$^{†}$</td>
</tr>
</tbody>
</table>

$^{†}$p > 0.05
As pointed out by Dougados (1996), there are several issues to consider when introducing a new questionnaire or new tools for epidemiological surveys. A new tool will be very useful only if it possesses better characteristics such as rapidity, facility, validity, and reliability; otherwise, existing questionnaires might be preferred. Of course, submaximal and maximal laboratory exercise tests (Åstrand and Rodahl, 1994) and maximal multistage field tests (Léger and Lambert, 1982) have been used successfully but are not practical for epidemiological studies. The Huet questionnaire does not measure VO₂ max as accurately as direct measurement but it does provide quite correct data for epidemiological studies. Besides, it is a simple and inexpensive tool compared to some other questionnaires.

CONCEPTS BEHIND THE HUET QUESTIONNAIRE

A questionnaire must measure what it is designed to measure. The choice of VO₂ max as the gold standard seems to be the best reference for evaluating cardiorespiratory fitness because this measure is scientifically codified and validated (Schoeller and Van Santen, 1982) and is inversely related to all-cause mortality (Blair et al., 1989). However, it is not certain whether the key factor is high fitness level per se or the fact that one must be active by expending high energy to be fit.
Although \( \text{VO}_2 \text{max} \), PA, and EE may each have their own relationship with health-related fitness (Blair et al., 2001), they are also well related to each other. Hence, a high \( \text{VO}_2 \text{max} \) enables one to perform high-level PA and thus reach a high level of EE. Reciprocally, a high level of EE or PA is a training stimulus for \( \text{VO}_2 \text{max} \) improvement. Furthermore, when \( \text{VO}_2 \text{max} \) is measured with a questionnaire partly based on PA habits as in the present study, it is difficult to distinguish \( \text{VO}_2 \text{max} \) and PA. Still, other elements (body composition, age, gender, smoking habits, disease status) are being used to predict \( \text{VO}_2 \text{max} \), and thus we cannot assume that the Huet questionnaire is strictly measuring PA. Nevertheless, a major part of the Huet questionnaire deals with PA, and the fact that a high correlation was obtained between the Huet questionnaire and \( \text{VO}_2 \text{max} \) confirms the link between PA and \( \text{VO}_2 \text{max} \). On the other hand, however, \( \text{VO}_2 \text{max} \) is not total fitness and we do not know whether other components of health-related fitness would be better indicators of morbidity and mortality.

**COMPARISON WITH OTHER QUESTIONNAIRES**

That being said, physical activity questionnaires are not always well correlated with \( \text{VO}_2 \text{max} \). Hence, in a simultaneous evaluation of 10 commonly used physical activity questionnaires, Jacobs et al. (1993) reported a wide range of correlations from 0.07 to 0.63, with 6 of them showing a correlation above 0.50 with treadmill performance in 64 subjects. The QAPSE questionnaire was highly correlated to \( \text{VO}_2 \text{max} \) measured on a cycle ergometer \((R = 0.92, n = 120, p < 0.0001)\) (Berthouze et al., 1995). The different intensity levels of the Minnesota Leisure Time Physical Activity Questionnaire were initially validated with a progressive treadmill stress test \((R = 0.45, n = 175)\) (Taylor et al., 1978). In a review of the questionnaires used in the English language literature, Boisvert et al. (1988) reported that the Morrison questionnaire was also well correlated with maximal oxygen uptake \((R = 0.67)\). It classifies subjects in 8 levels of practice.

In fact, first-generation questionnaires, long and tedious, specifically designed to assess physical activity at home, work, and leisure distinguishing between low and high intensity, usually yield low correlation (0.01 to 0.45) with \( \text{VO}_2 \text{max} \) (Andersen et al., 1984; Blair et al., 1985; Bouchard et al., 1983; De Backer et al., 1981; Godin and Shephard, 1985; Skinner et al., 1966; Sobolski et al., 1988; Taylor et al., 1978). On the contrary, recent questionnaires, specifically developed to predict \( \text{VO}_2 \text{max} \) from physical activity patterns chosen among a list of 7 to 10 levels, appear to yield better correlations (0.60 to 0.90) with \( \text{VO}_2 \text{max} \) (Bruce et al., 1973; George et al., 1997; Heil et al., 1995; Jackson et al., 1990, Kolkhorst and Dolgener, 1994; Matthews et al., 1999; Morrison et al., 1984; Whaley et al., 1995). Matthews et al. (1999) obtained good correlation \((R = 0.86, \text{SEE} = 5.7, n = 799)\). Moreover, 83% of all subjects were either classified correctly or within one quintile of \( \text{VO}_2 \text{max} \). The Huet questionnaire with its correlation of 0.88 is quite comparable to this other type of approach.

Sometimes questionnaires are validated with aerobic field tests. The “Teenager” QAPSE was validated on a sample of 74 healthy volunteers ages 11.5 to 16 years using the aerobic 20-m shuttle run test and yielded a good correlation \((R = 0.57, p = 0.0001)\) (Gautheron, 1994). The French version of the Baecke Physical Activity Questionnaire was tested on 118 men ages 30–58 years and yielded sport
activity and leisure time indices that were positively related to \( \dot{V}O_2 \text{max} \) (\( R = 0.53 \) and 0.44, respectively, \( p < 0.001 \)) (Bigard et al., 1992). In that survey, \( V_2 \text{max} \) was also assessed with the 20-m shuttle run test (Léger and Gadoury, 1989). It could be argued that predicted \( V_2 \text{max} \) using field tests as criteria to validate questionnaires is not as good as direct \( V_2 \text{max} \) laboratory assessment. Still, these tests are generally well correlated with \( V_2 \text{max} \) (Léger and Gadoury, 1989; Léger and Lambert, 1982) and not affected by measurement errors that often affect highly sophisticated and automated \( V_2 \text{max} \) measurement systems.

SIMPLICITY AND RELIABILITY

Constructing and validating an instrument is a long and tedious task. A tool that can only be administered and decoded by experts is not particularly useful due to its difficulty and cost. The Huet questionnaire does not appear to be a difficult instrument for subjects. It can be administered by mail or telephone and does not require expensive equipment. Finally, decoding is simple and rapid with a personal computer or even a small calculator for calculating \( V_2 \text{max} \). The questionnaire does not require experts to administer it or decode it.

Like any other scientific tool, questionnaires must have not only good validity but also good reliability. The Huet questionnaire has proved to be quite reliable (ICC = 0.988) within a 6-week interval. According to McDowell and Newell (1987), this time lapse is sufficiently long to forget the answers and short enough to avoid important changes in usual behavior and \( V_2 \text{max} \). The administration setup must also be controlled to reduce variability. Self-administered or mailed questionnaires seem to be less reliable than interviews, but there are no other factors such as technical instruments, high education level, or financial contribution that could affect reliability. The written instructions on how to fill out the questionnaire must be simple, straightforward, precise, and similar for all: “This questionnaire asks questions about your daily physical activity. Answer all the questions to the best of your knowledge. Thank you!”

SENSITIVITY AND PRACTICAL ASPECTS

The sensitivity of a questionnaire is an important issue and depends on how well it reflects changes in the observed phenomenon, i.e., changes in physical activities or fitness level. We did not attempt to verify this aspect in the present work. On the other hand, the questionnaire does appear to discriminate well between subjects belonging to sedentary, active, and athletic categories. However, it is not accurate enough to differentiate among subjects within those categories, particularly in the athletic category which had elite cyclists with a wide range of performance (see explanation, next section).

Other features of the Huet questionnaire warrant attention. Although Huet’s questionnaire is based on questions related to physical activity, it appears to be too simple and too short to accurately assess physical activity or energy expenditure even though it properly predicts \( V_2 \text{max} \). Similarly, Jackson et al. (1990) used gender, age, body composition (BMI or skinfolds), resting heart rate, and self-reported activity to develop various functional aerobic capacity prediction models without using an exercise test. So we do not know if adding body composition...
estimates to the Huet questionnaire or resting heart rate would improve its validity as was the case in that study. When we added BMI to the Huet prediction from the two equations (males and females), the multiple regression revealed slightly higher correlations ($R = 0.90$, $SEE = 6.4$, $n = 108$). Thus adding BMI values to a lifestyle habit questionnaire may improve the accuracy of $\dot{V}O_2$max prediction.

The study by George et al. (1997) found high validity ($R = 0.88$) for a N-EX model, but questions on perceived functional ability to run 1 and 3 miles limit its broad applicability. The results confirmed the importance of these aspects for estimating functional aerobic capacity. However, the Huet questionnaire deals with a wide range of issues as mentioned above: intensity, duration, frequency of physical activity, intensity of work activities performed by individuals, training record, weight, smoking habits, etc. While sporting activities are privileged, the questionnaire nonetheless takes into account physical activities performed at work, as well as disease states and morphology data. However, it does not have items for personal activities (gardening, do-it-yourself work, daily walks, etc.) and activities of daily living (sleeping, grooming, reading, etc.). Some questionnaires do take these aspects into account because they could be considered as activities requiring an important intensity (Bouchard et al., 1983; Caspersen et al., 1985). So for the Huet questionnaire, a person who does not participate in any sports is considered sedentary even though he or she could engage in other quite strenuous types of physical activity not mentioned in the questionnaire.

Another limitation of the Huet questionnaire, as with any that are using age and gender to predict $\dot{V}O_2$max, is that any female subject will automatically be granted a $\dot{V}O_2$max value lower than the male equivalent to the average difference between males and females, even though real values are sometimes similar. Similarly, an older fit individual having a real $\dot{V}O_2$max higher than that of a young sedentary subject may be granted a lower predicted $\dot{V}O_2$max. Furthermore, we need to recognize that with the maximal score obtained with the Huet questionnaire, predicted $\dot{V}O_2$max could not be higher than 70 to 40 ml·kg·min$^{-1}$ for males or 52 to 34 ml·kg·min$^{-1}$ for females ages 18 to 65 years. And it could not be lower than 42 to 32 ml·kg·min$^{-1}$ for males or 30 to 16 ml·kg·min$^{-1}$ for females of same age span. That may not be a major problem in an epidemiological study, but it is a problem in predicting $\dot{V}O_2$max of endurance athletes or of very sedentary subjects.

Age and gender have more discriminating power than scores to the questionnaire. In Figure 1, all subjects with $\dot{V}O_2$max above 62 ml·kg·min$^{-1}$ were underestimated. It seems that the Huet questionnaire with its equations underestimates highly fit individuals. But when we plotted with different symbols for each gender-age combination, we found that this interpretation is due to a much wider range of directly measured $\dot{V}O_2$max values in younger age groups. In fact in younger age groups, the less fit individuals are much overestimated. With a wider range of measured $\dot{V}O_2$max values in the older group, we would probably not see this kind of inflexion at the high end of the scatterplot but we would have a greater SEE value. The scatterplot with different age-gender symbols also confirmed the low discriminative effect of the questionnaire scores on predicted $\dot{V}O_2$max values.

Of course, the fact that original validations of questionnaires are not usually based on a sample with a large proportion of highly fit subjects may also introduce some bias in the prediction of $\dot{V}O_2$max. Furthermore, it is possible that the ques-
tionnaire does not discriminate fit individuals because they get about the same amount of points as slightly less fit ones. Other questionnaires may have similar problems if the original validation data sets of subjects do not contain many trained subjects, and if age is included as a predictor with a wide age-range sample. Prediction could be slightly improved for fitter individuals using regressions of Figure 1 to correct predicted values.

Instead, if we delete age and gender from the prediction to get rid of systematic errors associated with these variables and just consider some Huet questions and BMI of the subjects, we get a new prediction equation:

\[ \text{V. O}_2 \text{max} = 66.76099 + 5.05261Q3 + 2.51437Q9 - 1.59313\text{BMI} + 2.45654Q1, \]

\[ R = 0.852, \text{SEE} = 7.65, n = 107, \]

where Q1, Q3, and Q9 are scores to Questions 1, 3, and 9 of the Huet questionnaire. That yielded better correlation and SEE than using BMI, total of Q1 to Q8, and total of Q9 to Q10 \( (R = 0.84, \text{SEE} = 7.9, n = 108) \). Also, compared to the Huet equation, that equation has similar \( R \) and \( \text{SEE} \) values without the artefact due to age and gender, and better discriminating power of the other predictors (Figure 2). For instance, predicted \( \text{VO}_2 \text{max} \) values of males ages 20 to 29 (filled square symbols) range from 45 to 65 ml·kg\(^{-1}\)·min\(^{-1}\) only using Huet equations that include age and gender (Figure 1), while predicted values using the new multiple regression that include BMI, but not age or gender, range from 28 to 69 ml·kg\(^{-1}\)·min\(^{-1}\), which is closer to real the \( \text{VO}_2 \text{max} \) range (30 to 75 ml·kg\(^{-1}\)·min\(^{-1}\)). Thus we think that only predictors that are affected by lifestyle or training should be included in a prediction model for \( \text{VO}_2 \text{max} \) which excludes age and gender.

Finally, subjectivity is a general limitation of questionnaires. The subjects provide their own self-assessment of their physical activity: “What kind of physical activities...” or “How many times a month have you practiced...” This is an inherent problem for all questionnaires assessing quality of life, pain, or any precise parameter such as \( \text{VO}_2 \text{max} \).

**Conclusion**

In conclusion, the Huet questionnaire or some of its components constitute a valid and reliable tool for assessing \( \text{VO}_2 \text{max} \). It is simple, low cost, easy to use, quick to decode, and available in English and French versions. When precise instructions are provided beforehand, self-administration by mail or telephone is also possible. It constitutes a compromise between objective measurements, which are expensive and impractical for epidemiological studies, and former physical activity or energy expenditure questionnaires, which are difficult and tedious to administer and decode. The Huet questionnaire is a very simple and useful tool for assessing physical fitness in epidemiological studies, at least for the type of population sampled in our study. We are currently assessing the validity and reliability of the Huet questionnaire with children and disabled subjects. Now we will work on various populations and make equation adjustments to improve the accuracy of the questionnaire for assessing fitness in epidemiological studies and compare its validity with other nonexercise questionnaires such as those using a sole question on physical activity rating between 7 to 10 levels of practice (Bruce et al., 1973;
George et al., 1997; Heil et al., 1995; Jackson et al., 1990; Kolkhorst and Dolgener, 1994; Morrison et al., 1984; Whaley et al., 1995).

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References


APPENDIX

Questionnaire to Predict Maximal Oxygen Uptake

Benoît Huet, Dépt. d’éducation physique, Université de Montréal, 1984
(English adaptation by Luc Léger)

Note: Put the number corresponding to your choice in the blank space in the right margin.

1. What kind of physical effort does your job (or studies) require?
   • Intense (e.g., lumberman, furniture mover) ....................................................2
   • Relatively intense (e.g., constructor, messenger) ...........................................1
   • Not so intense (e.g., department store salesman) ......................................... 0.5
   • Sedentary (e.g., white collar, office worker, student) ....................................0

2. What kind of physical activities do you usually do?
   • Those that make you sweat or breath heavier on a regular basis (e.g., jogging, cross-country, skiing) .......................................3
   • Those that make you breath heavier intermittently (e.g., walking, racquetball) .................................................................2
   • Those that make you breath slightly heavier (e.g., walking, softball) .................................................................1
   • Easy or accuracy activities (v.g., bowling, archery) ....................................0.5

3. During this past year, how many times a month have you practiced your favorite physical activity?
   • 0 to 4 times per month ...................................................................................0
   • 5 to 8 times per month ....................................................................................1
   • 9 to 12 times per month ..................................................................................2
   • 13 times or more per month .......................................................................... 3

4. What is the usual duration (minutes) of your exercise period?
   Note: If your answer to question 2 was 0.5, record “0” in the right margin
   • Less than 15 min ............................................................................................0
   • 16 to 30 min .................................................................................................1
   • 31 to 45 min ...............................................................................................2.5
   • 46 to 60 min ...............................................................................................3.2
   • 61 min or more ............................................................................................3.5

(continued)
5. How do you usually qualify your exercise sessions:
   Note: If your answer to question 2 was 0.5, record “0” in the right margin
   • Very easy ...............................................................1
   • Easy ...............................................................1.5
   • More or less difficult ...............................................2.5
   • Difficult .............................................................3
   • Very difficult ......................................................3.5

6. When age 10 to 16 years old, did you do physical exercises on a regular basis?
   • On a regular basis (more than 4 times a week) .........................2
   • Not often (3 times or less a week) ............................................1
   • Rarely (1 time or less a week) ...............................................0

7. How many cigarettes a day do you smoke?
   • 0 to 2 .................................................................0
   • 3 to 15 .............................................................–1
   • 16 or more ........................................................–2

8. According to your own judgment, how much extra (fat) weight do you have?
   • 0 to 1 kg (0 to 2 lbs) ....................................................1
   • 1.5 to 3 kg (3 to 6 lbs) ..............................................0
   • 3.5 to 5 kg (7 to 10 lbs) ............................................–1
   • 5 kg or more (11 lbs or more) ....................................–2

9. Did you ever perform physical activities or sports in a competition set-up?
   • No ............................................................................0
   • Yes, regional events (e.g., popular racing) .........................3
   • Yes, provincial or state events ........................................4
   • Yes, national or international events.................................5

10. Do you suffer from any of the following pathological conditions and nevertheless have your physician’s permission to practice intense and regular physical activities?
    Diabetes; hypertension, cardiac, or respiratory problems; asthma; obesity; arthritis
    • Yes ...........................................................................–5
    • No ............................................................................0

With X1 (sum of Q-1 to Q-8) and X2 (sum of Q-9 to Q-10), VO₂max in ml·kg⁻¹·min⁻¹:
Males: Y = 45.334 – (0.322 * age) + (1.729 – 0.018 * age) * X1 + X2
Females: Y = 37.145 – (0.316 * age) + (0.951 – 0.004 * age) * X1 + X2

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Appendix (Cont.)