ARE CARDIORESPIRATORY FITNESS AND WALKING PERFORMANCE ASSOCIATED WITH SELF-REPORTED QUALITY OF LIFE AND WORK ABILITY?

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Abstract

Objective: In Finland, testing cardiorespiratory fitness (VO₂max) is popular in health promotion programs and work ability evaluations. The most common instruments used for this purpose are the submaximal cycle ergometer test, and the 2-km walking test. However, limited data exist on the associations between VO₂max and wellbeing in working age adults. The aim of the study was to evaluate how the measured (cycle ergometer) and the estimated (walking test) VO₂max and walking performance are associated with health-related quality of life and work ability. Materials and Methods: The subjects were 104 middle-aged men workers (45–55 years old), mostly from the construction and manufacturing industries. VO₂max was directly measured by a maximal exercise test on a cycle ergometer. The 2-km walking test parameters were the walking time, predicted VO₂max, and fitness index. Health-related quality of life was assessed with the RAND-36 questionnaire which was further divided into physical dimensions (P-RAND-36) and mental dimensions (M-RAND-36). Perceived work ability was assessed with the work ability index (WAI) in a subgroup of 51 subjects. Results: The 2-km walking test parameters significantly predicted the score on P-RAND-36 (r² = 0.18, p = 0.001), and correlated significantly with WAI. The directly measured VO₂max was not associated with P-RAND-36, M-RAND-36 or WAI. Conclusions: The inexpensive 2-km walking test may be more useful when evaluating the quality of life and work ability, compared to the more expensive direct measurement of one’s cardiorespiratory fitness in a laboratory.

Key words: Health-related quality of life, Work ability, Cardiorespiratory fitness, Walking performance

INTRODUCTION

Perceived health, health-related quality of life (HRQoL), work ability and physical fitness may be related to the future health status, functioning, and mortality [1–4]. Therefore, the assessment of a person’s perspective of these parameters, combined with objective findings, can be relevant for initiating preventive and supportive occupational health programs. Today, this promotion of health and work ability is even more important because the workforce is ageing rapidly in many countries [5]. Several instruments are available for assessing HRQoL [6], but the ones for work-related perspectives are mostly
The Finnish Institute of Occupational Health has developed a questionnaire-based Work Ability Index (WAI) to define a person’s work ability [7]. In an 11-year follow-up study on 6259 elderly municipal workers, a poor WAI score was a strong predictor of future work disability and even mortality [2]. A follow-up study with 818 workers showed a significant relationship between WAI and leadership, ergonomics, and leisure-time physical exercise [8].

METHODS

Subjects

The subjects were 104 middle-aged men workers (50.2±2.8, range 45–55 years) participating in occupationally-oriented program promoting health and work ability. They were healthy but having mild symptoms of musculoskeletal or psychological strain. Those having cardiovascular diseases were excluded. Over two thirds of the subjects worked in the construction and manufacturing industries.

The group-based health promotion program was organized by occupation, age, and perceived work ability. An average group consisted of 8 to 10 participants from the same workplace and occupation. The participants were selected based on physician’s referral. The inclusion criteria for the program were defined by the funding agency, the Finnish Social Insurance Institution, and were as follows: (i) at least three years’ experience in the current job, (ii) no diseases causing sick leave of more than 60 days during the past two years, (iii) no diseases that prevent participation in the program including also different kinds of physical activity, and (iv) motivation to stay in the job.

The design and protocols of the present study were approved by the local ethics committee and the subjects gave their written informed consent.

Questionnaires

HRQoL was assessed with the RAND 36-item Health Survey [18]. RAND-36 is used to evaluate the following eight health dimensions: (i) general health perception, (ii) physical functioning, (iii) physical role functioning, (iv) bodily pain, (v) emotional role functioning, (vi) emotional wellbeing, (vii) social functioning, and (viii) energy versus fatigue. The first four health dimensions build up the physical summary score (physical health, P-RAND-36) and the submaximal treadmill walking in 198 occupationally active persons.

The aim of the present study was to evaluate how the directly measured (cycle ergometer) and the estimated (walking test) VO₂max and walking performance are associated with HRQoL and work ability.
last four dimensions, the mental summary score (mental health, M-RAND-36) [19].

Perceived work ability was assessed with WAI in a subgroup of 51 subjects [20]. WAI consists of the following seven items: (i) current work ability compared with lifetime best, (ii) work ability in relation to the demands of the job, (iii) number of current diseases diagnosed by a physician, (iv) estimated work impairment due to disease, (v) sick leaves during the past year, (vi) own prognosis of work ability two years from now, and (vii) mental resources. The summary score can vary from 7 to 49 and is divided into four work ability categories: poor (7–27 points), moderate (28–36 points), good (37–43 points) and excellent (44–49 points).

Physical activity was assessed with a standardized questionnaire modified from Oja [21].

Physical assessments
A medical examination was carried out before the physical tests and included measurements for risk evaluation and physical health profile; resting electrocardiography, blood pressure, waist circumference, and body height and weight. Body mass index (BMI) was calculated from body height and weight.

Two tests were used to evaluate physical performance capacity:

1. \( \text{VO}_{2}\text{max} \) was directly measured during a maximal incremental exercise test on an electrically braked cycle-ergometer (Ergoline 900, Medith, Germany). The subject exercised for 3 minutes at each load until exhaustion. During the test, the ventilatory and gas exchange variables were continuously measured by Medical Graphics CPX/D metabolic cart (Medical Graphics Corporation, St. Paul, USA).

2. The 2-km walking test on an indoor track was performed a week after the cycle ergometer test. In the test, the subjects were instructed to walk as fast as possible for 2 kilometres. Walking time, heart rate at the end of walking (Polar A3, Polar Electro, Kempele, Finland), BMI, and age were used to predict \( \text{VO}_{2}\text{max} \) and calculate the fitness index for each subject [22].

Statistics
The data were analyzed statistically by the SPSS statistical analysis system (version 12.0, SPSS Inc.). The obtained RAND-36 scores were compared with the RAND-36 population values for the Finnish men aged 45–54 years, using confidence intervals [23].

We calculated and the Pearson correlation coefficients between WAI, RAND-36, P-RAND-36, M-RAND-36, the different items of RAND-36, the results of the maximal cycle-ergometer test and the 2-km walking test. To evaluate the predictive power of both the physical performance tests for P-RAND-36 and WAI, the data were further analyzed with multiple linear regression analysis. In the first analysis, the four results for the physical performance (the last workload and \( \text{VO}_{2}\text{max} \) in the maximal cycle-ergometer test, as well as \( \text{VO}_{2}\text{max} \) and the index based on 2-km walking test) were selected as the independent variables, and the P-RAND-36 or WAI as the dependent variables in each model. In further analysis, only the variables significantly explaining the variance in the P-RAND-36 or WAI were entered in the final model. The results were considered significant when \( p < 0.05 \).

RESULTS
The subjects’ mean body height, weight, BMI, and waist circumference were 1.76±0.07 m, 87.2±8.4 kg, 28±1.2 and 100±6.1 cm, respectively. The subgroup of 51 subjects for whom WAI was reported did not differ significantly from the other subjects in body height, body weight, waist circumference or age. One third (32%) of the subjects were current smokers. The level of physical activity of the study participants varied widely. Only 5% of them were exercising at least four times a week, one third (36%) 2–3 times a week and also about one third (32%) reported exercising less than once a week within the last 12 months. The most popular modes of activity were walking, jogging, gym exercises, skiing, and swimming.

Physical fitness characteristics are given in Table 1. \( \text{VO}_{2}\text{max} \) level was assessed with the direct ergometer test and the 2-km walking test. Both the measured and predicted \( \text{VO}_{2}\text{max} \) values were, on average, at a similar level and
BMI correlated significantly with fitness index ($r = -0.75$, $p = 0.000$ and $r = -0.43$, $p = 0.000$, respectively), but not with age ($r = 0.17$, $p = 0.14$).

To study how well our subjects represent the general population, we made a comparison to a random sample of same-age Finnish men, using RAND-36. There were no significant differences between our subjects and the Finnish men with respect to the different items of RAND-36 that were considered (Table 2).

As estimated by WAI, the work ability was poor among 8%, moderate among 25%, good among 51% and excellent among 16% of the subjects. There was a highly significant correlation between WAI and P-RAND-36 ($r = 0.63$, $p = 0.000$). The correlations between WAI and the different items of P-RAND-36 were higher than the correlations between WAI and the items of M-RAND-36 ($r = 0.47–0.64$, $p = 0.001–0.000$; $r = 0.31–0.19$, $p = 0.035–0.19$, respectively).

The walking time and the estimated VO$_2$ max (the 2-km walking test) correlated significantly with P-RAND-36 and the physical items of RAND-36 except for the bodily pain. The maximal load achieved in the cycle-ergometer test correlated significantly with the general health item of RAND-36. The fitness index and the VO$_2$ max based on the 2-km walking test correlated significantly with WAI ($r = 0.30$, $p = 0.046$; $r = 0.33$, $p = 0.031$, respectively) (Table 3).

Table 1. Physical fitness characteristics of the middle-aged men studied. Directly measured maximal oxygen consumption (VO$_2$ max), maximal load in the cycle-ergometer test (watts), walking time in the 2km walking test (min), estimated VO$_2$ max value and fitness index based on the 2-km walking test results

<table>
<thead>
<tr>
<th></th>
<th>Mean (SD)</th>
<th>Number of subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>VO$_2$ max (ml × kg$^{-1}$ × min$^{-1}$)</td>
<td>32.5±4.6</td>
<td>86</td>
</tr>
<tr>
<td>Maximal load (watts)</td>
<td>205±34</td>
<td>86</td>
</tr>
<tr>
<td>2-km walking time (min)</td>
<td>16.5±1.4</td>
<td>83</td>
</tr>
<tr>
<td>VO$_2$ max by 2-km walking test (ml × kg$^{-1}$ × min$^{-1}$)</td>
<td>33.8±6.1</td>
<td>81</td>
</tr>
<tr>
<td>2-km fitness index</td>
<td>85.6±15.5</td>
<td>83</td>
</tr>
</tbody>
</table>

Means and standard deviations (SD) are given. Fitness index categories according to the UKK 2-km walking test manual [23]: < 70 markedly lower than average, 70–89 a little lower than average, 90–110 average, 111–130 a little higher than average, and > 130 markedly higher than average.

indicated a lower than average aerobic fitness. According to the 2-km fitness index [24], in 57% of the subjects, the fitness index was markedly lower (less than 70) or little lower (70–89) than average. Only 6% (five subjects) had a little higher than average (111–130) fitness index. None of the subjects presented fitness index markedly higher than average (130). The correlation between the measured and predicted VO$_2$ max was 0.46 ($p = 0.000$).

BMI, age, and walking time predicted 68% of the variance in the fitness index in the walking test. Walking time and

Table 2. Subjects' health-related quality of life (n = 96) in comparison with reference values for the Finnish male population aged 45–54 years (n = 180)

<table>
<thead>
<tr>
<th>Rand-36 dimension</th>
<th>Subjects</th>
<th>Finnish men</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>95% CI</td>
</tr>
<tr>
<td>General health perception</td>
<td>60.6</td>
<td>56.7–64.4</td>
</tr>
<tr>
<td>Physical functioning</td>
<td>85.3</td>
<td>81.7–88.9</td>
</tr>
<tr>
<td>Physical role functioning</td>
<td>74.0</td>
<td>66.6–81.3</td>
</tr>
<tr>
<td>Bodily pain</td>
<td>68.9</td>
<td>63.9–73.8</td>
</tr>
<tr>
<td>Emotional role functioning</td>
<td>81.4</td>
<td>75.1–87.8</td>
</tr>
<tr>
<td>Emotional wellbeing</td>
<td>76.1</td>
<td>72.9–79.4</td>
</tr>
<tr>
<td>Social functioning</td>
<td>85.0</td>
<td>81.1–88.9</td>
</tr>
<tr>
<td>Energy</td>
<td>67.3</td>
<td>63.6–71.0</td>
</tr>
</tbody>
</table>

Means and 95% confidence intervals are given.
The aim of this study was to investigate how HRQoL evaluated with RAND-36 and work ability assessed with WAI correlate with the physical fitness tested by two different methods. Our main finding was that the 2-km walking test significantly predicted the score on P-RAND-36 as well as significantly correlated with WAI. The directly measured VO₂ max was not related to the wellbeing measures. As expected, M-RAND was not associated with the results of the physical fitness tests.

### Table 3. Correlation coefficients (r) between the physical fitness test [directly measured maximal oxygen consumption (VO₂ max, ml × kg⁻¹ × min⁻¹), maximal load in the cycle-ergometer test (watts), walking time in the 2-km walking test (min), estimated VO₂ max value, and fitness index based on the 2-km walking test], the work ability index (WAI), and physical items of RAND-36

<table>
<thead>
<tr>
<th></th>
<th>WAI</th>
<th>P-RAND-36</th>
<th>General health perception</th>
<th>Physical functioning</th>
<th>Physical role functioning</th>
<th>Bodily pain</th>
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<tr>
<td>VO₂ max</td>
<td>r = 0.11</td>
<td>r = 0.11</td>
<td>r = 0.12</td>
<td>r = 0.17</td>
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<tr>
<td></td>
<td>n = 43</td>
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<td>n = 76</td>
<td>n = 76</td>
<td>n = 76</td>
<td>n = 76</td>
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<tr>
<td>Maximal load</td>
<td>r = 0.15</td>
<td>r = 0.20</td>
<td>r = 0.24*</td>
<td>r = 0.18</td>
<td>r = 0.13</td>
<td>r = 0.17</td>
</tr>
<tr>
<td></td>
<td>n = 43</td>
<td>n = 76</td>
<td>n = 76</td>
<td>n = 76</td>
<td>n = 76</td>
<td>n = 76</td>
</tr>
<tr>
<td>2-km walking time</td>
<td>r = -0.20</td>
<td>r = -0.27*</td>
<td>r = -0.28*</td>
<td>r = -0.24*</td>
<td>r = -0.23*</td>
<td>r = -0.21</td>
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<tr>
<td></td>
<td>n = 44</td>
<td>n = 75</td>
<td>n = 75</td>
<td>n = 75</td>
<td>n = 75</td>
<td>n = 75</td>
</tr>
<tr>
<td>VO₂ max by 2-km walking test</td>
<td>r = 0.33*</td>
<td>r = 0.29*</td>
<td>r = 0.30*</td>
<td>r = 0.25*</td>
<td>r = 0.24*</td>
<td>r = 0.20</td>
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<tr>
<td></td>
<td>n = 43</td>
<td>n = 73</td>
<td>n = 73</td>
<td>n = 73</td>
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<td>n = 73</td>
</tr>
<tr>
<td>2-km fitness index</td>
<td>r = 0.30*</td>
<td>r = 0.17</td>
<td>r = 0.23*</td>
<td>r = 0.16</td>
<td>r = 0.12</td>
<td>r = 0.11</td>
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<tr>
<td></td>
<td>n = 44</td>
<td>n = 75</td>
<td>n = 75</td>
<td>n = 75</td>
<td>n = 75</td>
<td>n = 75</td>
</tr>
</tbody>
</table>

P-RAND-36 is the summary score for the four physical items of RAND-36.

*P < 0.05.

### Table 4. Correlation coefficients (r) between the physical fitness test [directly measured maximal oxygen consumption (VO₂ max, ml × kg⁻¹ × min⁻¹), maximal load in the cycle-ergometer test (watts), walking time in the 2-km walking test (min), estimated VO₂ max value, and fitness index based on the 2-km walking test] and mental items of RAND-36

<table>
<thead>
<tr>
<th></th>
<th>M-RAND-36</th>
<th>Energy</th>
<th>Emotional role functioning</th>
<th>Emotional wellbeing</th>
<th>Social functioning</th>
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<tbody>
<tr>
<td>VO₂ max</td>
<td>r = -0.11</td>
<td>r = -0.01</td>
<td>r = 0.06</td>
<td>r = -0.03</td>
<td>r = 0.06</td>
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<tr>
<td></td>
<td>n = 76</td>
<td>n = 76</td>
<td>n = 76</td>
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</tr>
<tr>
<td>Maximal load</td>
<td>r = 0.06</td>
<td>r = 0.06</td>
<td>r = 0.10</td>
<td>r = -0.03</td>
<td>r = 0.10</td>
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<tr>
<td>2-km walking time</td>
<td>r = -0.13</td>
<td>r = -0.06</td>
<td>r = -0.18</td>
<td>r = -0.07</td>
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<tr>
<td>VO₂ max by 2-km walking test</td>
<td>r = 0.10</td>
<td>r = 0.06</td>
<td>r = 0.12</td>
<td>r = -0.01</td>
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<td></td>
<td>n = 73</td>
<td>n = 73</td>
<td>n = 73</td>
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<td>n = 73</td>
</tr>
<tr>
<td>2-km fitness index</td>
<td>r = 0.07</td>
<td>r = 0.03</td>
<td>r = 0.11</td>
<td>r = -0.03</td>
<td>r = 0.11</td>
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<tr>
<td></td>
<td>n = 75</td>
<td>n = 75</td>
<td>n = 75</td>
<td>n = 75</td>
<td>n = 75</td>
</tr>
</tbody>
</table>

M-RAND-36 is the summary score for the four mental items of RAND-36.

No significant correlations were found between the measured physical performance and M-RAND-36 or its domains (Table 4).

In the multiple linear regression analysis, the measured level of physical fitness in different test modes did not explain the obtained WAI. However, the VO₂ max and fitness index based on the 2-km walking test did explain the P-RAND-36 score (standardized beta coefficients 1.2 and -1.0, p = 0.002 and p = 0.005, respectively). The r² of the final model was 0.18.

### DISCUSSION

The aim of this study was to investigate how HRQoL evaluated with RAND-36 and work ability assessed with WAI correlate with the physical fitness tested by two different methods. Our main finding was that the 2-km walking test significantly predicted the score on P-RAND-36 as well as significantly correlated with WAI. The directly measured VO₂ max was not related to the wellbeing measures. As expected, M-RAND was not associated with the results of the physical fitness tests.
Methodological considerations
Although the results for each of the RAND-36 items did not show any significant difference between the study population and a random sample of Finnish men of the same age, one should bear in mind that the findings of this study refer to a specially selected group attending a work ability promoting program. Further studies would be necessary to verify the present findings.

The correlation between the directly measured and estimated (with the 2-km walking test) VO\(_2\)max was modest (r = 0.46), and clearly lower than that reported earlier in obese and moderately active men (r = 0.75 and r = 0.79, respectively) [28]. The lower correlation in our study may be explained by the method the VO\(_2\)max was measured. We used a cycle-ergometer for direct measurement of VO\(_2\)max while in the earlier study by Oja et al. [24], VO\(_2\)max was measured directly during maximal uphill walking on a treadmill. One important factor reducing the correlation between the measured and estimated VO\(_2\)max values seems to be the walking speed, which is partly related to cardiorespiratory fitness, and partly to biomechanical factors. In fact, the 2-km walking test may also measure one’s walking ability (i.e. ability to walk without limitations related to musculoskeletal or cardiovascular health).

Physical fitness and quality of life
We found one earlier study on the associations of physical fitness and HRQoL in a relatively healthy population of working women [25]. In that study, there was no association between improved physical performance (measured by the 2-km walking test) and HRQoL (measured by COOP/WONCA charts). The difference in gender and the method of measuring HRQoL may partially account for the different results of this and the present study. The instruments used to assess HRQoL differ widely in their length and coverage [6]. RAND-36 contains nine items directly related to physical performance or functioning (running, sports, lifting and carrying, climbing stairs, walking short and long distances), whereas most of the other instruments have less precise questions on mobility functioning. Thus, our findings may reflect the properties of the RAND-36 questionnaire that may be more valid for our middle-aged men working in physically demanding jobs.

Physical fitness and work ability
The Finnish National Public Health Institute has recently completed a nationwide randomized project concerning the health status of the residents (Health 2000), which also included questionnaires on self-reported functional ability, working ability, and their limitations [26]. In men (n = 2438) aged 30 to 64 years, the highest odds ratio (34.5) concerning impairment in work ability was found among persons who could not or had difficulties walking 2 km compared with those who could walk 2 km without problems [26]. Our findings are consistent with the self-reported results of this population study: the measured walking performance was associated with work ability. Kaleta et al. [17] also found a significant correlation (r = 0.4) between WAI and VO\(_2\)max predicted from heart rate response to submaximal treadmill walking in 198 occupationally active persons. Considered together, these findings may indicate that the 2-km walking test is a more relevant method for assessing functional capacity in ordinary populations. Walking is a necessary basic function in daily life, and it is also the most popular leisure-time physical activity among adults both in the European Union and the United States [27,28] and, much more familiar than cycling. In addition, physical jobs often require walking, carrying, and stair climbing, especially outdoors in varying environmental conditions (e.g. in the construction industry).

Earlier studies on the physical fitness and work ability have been somewhat contradictory. In the study of Smolander et al. [13], the average WAI was relatively high (44 points) and did not improve during a 24 months’ follow-up even though the physical fitness (measured as peak oxygen uptake in incremental treadmill test) did improve. One explanation for the finding may be the ceiling effect, i.e. it is difficult to still improve high work ability. On the other hand, it is tempting to assume that the improved physical fitness supported the WAI to stay high during this 2-year follow-up study, but the lack of the control group makes such a conclusion speculative. In the study by Pohjonen [14], the asso-
ciations between VO$_2$max (measured with the submaximal cycle-ergometer test) and WAI in a 5-year follow-up were somewhat unclear. The average VO$_2$max indicated a high risk (OR 3.1) for decreased work ability compared with a good level of VO$_2$max, but the poor VO$_2$max value did not. In another study [29], VO$_2$max was estimated with a submaximal cycle-ergometer test, and work ability with WAI. The VO$_2$max significantly correlated with WAI in women performing mental work and men doing heavy physical job. Nygård et al. [30] found no relationship between estimated VO$_2$max and WAI in a sample of 137 municipal workers (mean age 55 years). They concluded that since VO$_2$max is not a work-related measure, it is of limited use in evaluating work ability. Naturally, the VO$_2$max is important for other purposes, for example, when documenting precise changes in fitness after physical training.

Theoretically, an increased physical activity and fitness may increase the person’s capacities to cope with the demands of everyday life, but the pathways to the global improvement of HRQoL or work ability may be very complicated due to many factors influencing these concepts. As more than two thirds of the subjects in the present study worked in physically demanding jobs, like construction and manufacturing, it was expected that the directly measured VO$_2$max would significantly correlate with WAI. In some jobs with very high physical demands, such as smoke-diving in fire-fighting, the safe execution of tasks is linearly related to the level of aerobic fitness [31]. In the physically less demanding jobs, the organizational and workplace factors (psychosocial, ergonomic) may be more important for work ability [8].

CONCLUSIONS

The results of this study tend to demonstrate a closer relationship between P-RAND-36, WAI, and walking ability than between P-RAND-36, WAI, and the maximal cycle-ergometer test. The 2-km walking test is easy to administer in groups. Thus, this inexpensive test may be more useful for estimating the quality of life and work ability than the more expensive direct measurement of cardiorespiratory fitness.

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