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ORIGINAL RESEARCH

Regular Exercise is Associated with a More Favorable Cardiovascular Risk Profile, Better Quality of Life, Less Depression and Less Psychological Stress

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Introduction: It is well documented that insufficient physical activity (PA) contributes substantially to cardiovascular diseases. The number of physically active people in Germany is still too low.

Methods: In ELITE study in Germany, 4602 participants are regularly examined for cardiovascular risk factors (CVRF). The aim is to motivate participants to improve their CVRF through individual recommendations and regular follow-up. Here, the PA data are presented in correlation with CVRF at baseline. A feature of this presentation is that the usual CVRF but also the effects on psychosocial factors were recorded simultaneously.

Results: Participants were divided into 3 groups based on their PA: 1. frequent exercise (FE): daily to 2–3x per week (41.4%), 2. moderate exercise (ME): 1x/week to 2x/month (28.8%), 3. rarely exercise (RE): 1x/month to not at all (29.8%). Age did not differ in the 3 groups. The most common CVRF was arterial hypertension, which decreased significantly with an increase in PA. Diabetes, nicotine, and increased BMI were also significantly less frequent in group 1. Antihypertensives were taken less frequently in this group 1. Less physically active participants were significantly more likely to have 3 or more additional CVRF. While group 1 consumed more fruit (64%) and considerably less pork, in group 2 and 3 only 58.3% and 50.3% respectively included fruit in their diet. FE also had a favorable effect on stress, depression and general well-being, all of which were significantly better in group 1.

Conclusion: Results confirm the beneficial influences of exercise on known CVRF and on psychosocial parameters. The prevalence of several CVRF per person at low levels of sport is of particular concern, as these participants would benefit most. During a 5-year follow-up, participants will receive intensive education on the need to increase PA. It remains to be seen how successful the effort will be.

Keywords: sport, exercise, cardiovascular risk factors, hypertension, diabetes, hypercholesterolemia, stress, ELITE, nutrition

Introduction

It is well established that insufficient physical activity contributes significantly to preventable CVDs such as diabetes mellitus, hypertension, and obesity. Increasing physical activity is crucial for future prevention success, especially of cardio- and cerebrovascular diseases, because exercise can improve most risk factors.[1–4] Nevertheless, the number of physically active people in Germany is still too low.

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According to Statista, 29% of Germans do not exercise.[5] So despite some improvements, the recommendations for improving lifestyle still reach far too few people affected.

This is because, despite some progress, control of cardio- and cerebrovascular risk factors is extremely inadequate. However, since the medical societies do not sufficiently reach the affected individuals, nor do they succeed in establishing the medical recommendations in the population in a solid and sustainable way, new impulses are needed. It is particularly difficult to motivate high-risk patients who have been inactive for many years to increase their physical activity. There is not a problem of knowledge, but a problem of implementation. Comprehensive medical evidence needs to be translated to the general population so that solid scientific knowledge results in public health benefits. In the long term, this will help to reduce the burden on hospitals and is therefore of great public interest.

In the ELITE study (Ernährung, Lebensstil und individuelle Information zur Verhinderung von Herzinfarkt, Schlaganfall und Demenz; German for: Nutrition, Lifestyle and Individual Information for the Prevention of Heart Attack, Stroke and Dementia) in northwestern Germany between Osnabrück and Oldenburg, cardiovascular risk factors are regularly examined in 4602 currently enrolled participants. Based on their personal results, the participants receive detailed and written prevention recommendations. The implementation of this recommendations is checked at follow-up examinations. In addition to the classic risk factors (blood pressure, laboratory values, nicotine, diabetes), data on nutrition, personal well-being, psychological stress, depression, and brain performance are determined. Physical activity is also recorded in a detailed questionnaire.[6–8]

The aim is to motivate more individuals to improve their risk profile through these individual recommendations and regular follow-up examinations. In the present paper, the data on physical activity are presented in correlation with the other data collected at baseline.

Methods

The methods of the ELITE study are described in detail elsewhere and will be repeated only briefly.[6–8] The invitation to participate in this prevention study was issued by the media, associations, companies and St.Josefs-Hospital Nephrology. Data collection is performed by interviews and examinations by trained teams (physician assistants, nurses/nurses, physicians) and by using standardized questionnaires completed by the participants. The following parameters are collected: Basic data: Age, gender, place of birth, current place of residence, school-leaving qualification, occupation, height, weight, blood pressure in sitting position on both arms, heart rate in sitting position, previous illnesses, nicotine consumption, hospitalization in the last 12 months, and current medication.

At the beginning, blood pressure measurements are taken on both sides after 5 minutes of quiet sitting in 3 conventional measurements with a 1-minute break between each measurement. The upper arm cuff is used to fit the respective circumference. The averaged value of the side with the higher values is included in the evaluation. The following laboratory values are determined, among others: Creatinine, eGFR, uric acid, iron, ferritin, transferrin saturation, glucose, HbA1c, total cholesterol, HDL cholesterol, LDL cholesterol, triglycerides, lipoprotein (a), blood count, liver values.

Participants were asked to complete standardized questionnaires on dietary habits, physical activity, occupational (job strain) and personal stress, quality of life, depression (BDI II Beck Depression Inventory), SHAPS-D (Snaith-Hamilton Pleasure Scale, German version). The questionnaires on nutrition were based on survey forms of the RKI (DEGS- Studie zur Gesundheit Erwachsener in Deutschland, German for: German Health Study in adults) to allow comparability with other studies.[9,10]

All participants receive detailed written recommendations for prevention based on their individual results. Detailed and emphatic recommendations for more exercise were given to individuals with insufficient physical activity. The data are presented mainly descriptive without a definite causal relationship.

Follow-up examinations take place in 1–2 yearly intervals, in which the implementation of the recommendations is checked.

Definitions

The participants were divided into 3 groups according to their level of physical activity after evaluation of the questionnaires: Group 1 –"frequent exercise" (FE): daily to 2–3x per week; Group 2- moderate exercise (ME): 1x/week to 2x/month; Group 3- rarely exercise (RE): 1x/month to not at all.

Hypertension is defined in this paper as blood pressure above 140/90 mmHg and /or blood pressure values below 140/90 mmHg under antihypertensive therapy. Other cardiovascular risk factors were BMI with values above 30 kg/m2, diabetes with HbA1c above 6.5% and/or

HbA1c below 6.5% with antidiabetic therapy and LDL cholesterol >130mg/dl. The nicotine abuse category was assigned to participants who indicated that they smoked, regardless of quantity.

Depression was identified using the BDI II questionnaire.[11] A score under 8 was considered no depression, between 9–19 minimal to slight depression and above 20 medium to severe depression. Participants who stated in the questionnaire that they experienced daily stress or 2–3 times a week were assigned to the category "high stress". To assess a sense of well-being, the Shaps-D score was used. A score between 0–1 was classified as well-being.

High fruit or meat consumption was defined as daily fruit or meat consumption.

Statistical Analysis

Statistical analysis was performed using the IBM SPSS Statistics software package, version 26. First, descriptive statistics, such as mean with standard error, minimum, maximum and the standard deviation (variance) were calculated from the available data. Furthermore, the data were presented graphically in the form of boxplots and histograms. Using the Kolmogorov–Smirnov test it was checked whether the data were normally distributed. The results of the Kolmogorov–Smirnov test show that the variables are generally statistically normally distributed.

Frequency tables were first created for the data of categorical variables. Further, this information was then summarized in the form of cross-tabulations. To test for possible correlations or dependencies between variables, the Pearson Chi test was used.

To compare two independent groups, the *t*-test for unrelated samples test was used. When there were more than two independent groups, a simple analysis of variance (ANOVA) was used. For subsequent pairwise post-hoc group comparisons, Bonferroni correction was applied. For non-normally distributed data, the Kruskal–Wallis test and the Mann–Whitney test were applied.

For all statistical tests, the usual significance level of α=0.05 was chosen. Thus, for tests that yielded a p-value less than 0.05, the null hypothesis was rejected, and the alternative hypothesis was accepted.

Results

38.7% of the 4602 participants are members of a sports club and 22% of a gym. 87.3% of the participants reported endurance sports. Only 23% of the participants practice a team sport. In addition, recreational activities such as walking and gardening are frequently reported by participants (92.4% and 87.7%). Frequent exercise (group 1) was performed by 41.4% of the participants, 28.8% are moderately active (group 2) and 29.8% are less or not active at all. (group 3). The discrepancy between the frequency of membership in a sports club and sufficient sports activity proves that many club members are no longer active in sports. The growing number of inactive members is a common problem in German clubs.

Age did not differ among the 3 groups. However, significantly more women were active in sports ($p< 0.001$) (Table 1). Mean systolic and diastolic blood pressure values showed the lowest values in group 1 and the highest values in group 3, although groups 2 and 3 took significantly more antihypertensives. Heart rate increased significantly with decreasing exercise. ß-blockers were taken significantly less often in group 3, which again underlines the improvement of heart rate by physical activity.

Figure 1 shows the age distribution of group 1. The under 30-year-olds had the highest exercise frequency of all age groups at 50.3%. In the age groups 30–39 and 40–49, the percentage with frequent exercise dropped significantly to 32.6% and 34.1%, respectively.

In the 50–79 year olds the percentages increase between 42.6% and 44.7%, which is positive. However, frequent exercise is still pleasing with 32.4% among the 80–89 year old. The participants in group 1 are frequently active in a sports club (55.1%) and a gym (66.2%) (moderate exercise: 30.7% and 24.6%, rarely exercise 14.1 and 9.2%).

Figure 2 shows the frequency of hypertension, diabetes mellitus, nicotine abuse and a BMI above 30 in the 3 exercise groups. The most frequent risk factor was arterial hypertension, which increased significantly with decrease in physical activity, despite more frequent use of antihypertensives. Diabetes, nicotine, and BMI were also significantly less frequent in group 1.

Table 2 shows the laboratory values. Group 3 showed slightly but significantly higher values for blood glucose and HbA1c. Triglycerides also showed the highest mean values in group 3. Significantly higher values were found in group 1 for HDL cholesterol. Uric acid increased significantly with decreasing physical activity.

Figure 3 shows the number of risk factors, i.e. hypertension, diabetes, nicotine abuse, LDL cholesterol above 130 mg/dl and BMI above 30 kg/m2 per person. Significantly more participants with no or only one risk factor were found in group 1, whereas individuals with 3 or more risk factors were significantly more likely to be in groups 2 and 3.

Table 1 Basic Data in 3 Sports Groups

	Frequent Exercise Group 1	Moderate Exercise Group 2	Rarely Exercise Group 3	Sign. Between 1 vs 2	Sign. Between 1 vs 3	Sign. Between 2 vs 3
Number n (%)	1905 (41.4%)	1325 (28.8%)	1372 (29.8%)	n.s.	n.s.	n.s.
Men n (%)	785 (41.2%)	598 (45.1%)	750 (54.7%)	n.s.	n.s.	n.s.
Women n (%)	1120 (58.8%)	727 (54.9%)	622 (45.3%)	n.s.	n.s.	n.s.
Age mean/ SD	51.6 ± 16.24	50.8 ± 14.97	52.2 ± 15.73	n.s.	n.s.	n.s.
Systolic BP in mmHg mean/SD	137.3 ± 16.1	138.1 ± 16.2	140.2 ± 17.5	n.s.	p<0.001	p=0.004
Diastolic BP in mmHg mean/SD	82.1 ± 9.7	83.3 ± 9.5	83.8 ± 10.5	p=0.003	p<0.001	n.s.
Heart rate in beats/ min mean/SD	71.5 ± 11.7	73.7 ± 11.8	74.9 ± 12.4	p<0.001	p<0.001	p<0.001
BMI in kg/m^2 mean/SD	25.7 ± 4.0	26.8 ± 4.5	27.8 ± 5.0	p<0.001	p<0.001	p<0.001
Antihypertensiva %	28.3	31.2	37.0	p=0.004	p<0.001	p=0.002
ß-Blocker %	12.8	14.4	20.4	n.s.	p<0.001	p<0.001
Statins %	8.5	8.5	10.2	n.s.	n.s.	n.s.

Abbreviation: BP, blood pressure.

Further, fruit and meat consumption were evaluated. Participants in Group 1 consumed more fruit (64%) than participants in Group 2 (58.3%) and Group 3 (50.3%). On the contrary, the consumption of meat was significantly lower in the Group 1 (Table 3). Frequent exercise also had a favorable effect on stress. High stress (defined as daily or

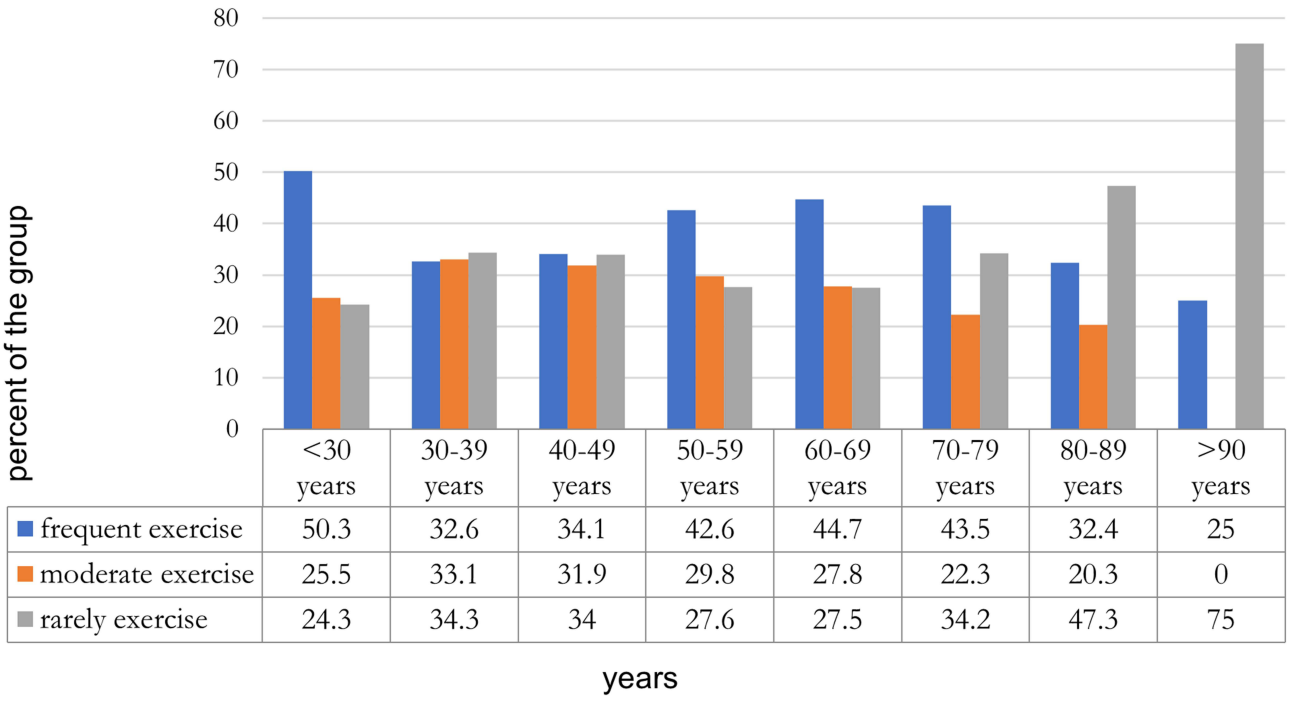
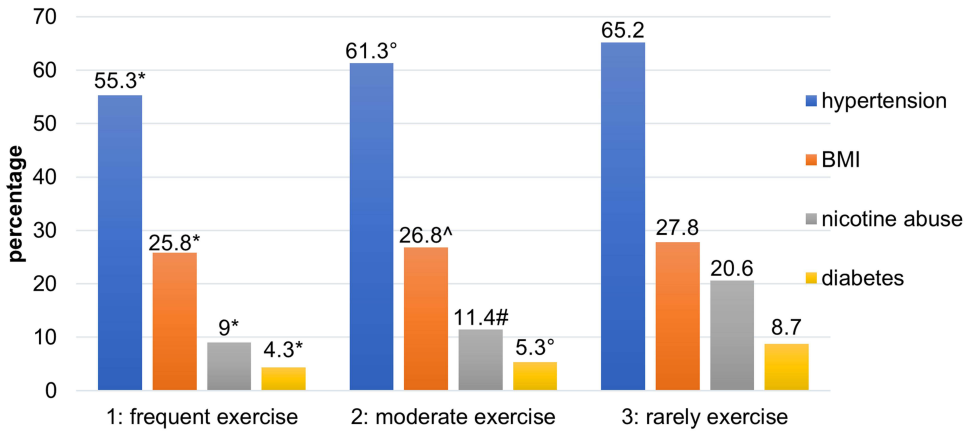


Figure 1 Age distribution among the participants in the three groups.



*p <0,001 Group 1 vs. Group 2 and 3, °p =0,020 Group 2 vs. Group 3, ^p <0,001 Group 2 vs. Group 3, #p =0,020 Group 2 vs. Group 1

Figure 2 Hypertension, BMI ≥ 30 kg/m2, nicotine abuse and diabetes mellitus in the 3 exercise groups.

−2-3 times/week stress at work and/or in private life) was found less often in group 1 (Table 3). The evaluation of the SHAPS-D questionnaire on well-being also showed a significantly better result in group 1.

Important results were also obtained in relation to depression (Figure 4).

Depressive symptoms occurred significantly less frequently in group 1 than in the other two groups. On the other hand, depressive symptoms were more frequent in the less active participants. (p< 0.001).

Discussion

This study showed that physical activity at the recommended level significantly improves cardiovascular risk factors, directly or indirectly, and also has beneficial effects on psychological stress, depression, well-being, and dietary behavior. The strength of this work is that all these aspects were surveyed simultaneously. Exercise can also reduce the new onset of risk factors and drug therapies. Many studies clearly show that higher physical activity is associated with lower risk of mortality and cardio- and cerebrovascular events in

Table 2 Laboratory Values in the 3 Groups

Laboratory Values	Frequent Exercise Group 1	Moderate Exercise Group 2	Rarely Exercise Group 3	Sign. Between 1 vs 2	Sign. Between 1 vs 3	Sign. Between 2 vs 3
	Mean ± SD	Mean ± SD	Mean ± SD			
Blood glucose mg/dl	91.3 ± 24.0	92.2 ± 27.5	95.2 ±27.9	n.s.	p<0.001	p=0.009
HbA1c %	5.3 ± 0.5	5.3 ± 0.6	5.4 ± 0.6	n.s.	p<0.001	p<0.001
Cholesterol µg/mL	205.3 ± 39.4	206.4 ± 37.8	205.0 ± 39.3	n.s.	n.s.	n.s.
Triglycerides µg/mL	139.8 ± 90.6	150.5 ± 91.4	169.1 ± 118.6	p=0.008	p<0.001	p<0.001
HDL- cholesterol µg/mL	64.3 ± 19.0	60.8 ± 18.1	56.4 ± 17.9	p<0.001	p<0.001	p<0.001
LDL-cholesterol µg/mL	129.0 ± 36.8	131.8 ± 35.5	131.8 ± 35.2	n.s.	n.s.	n.s.
LP(a) nmol/l	41.8 ± 60.0	41.0 ± 58.9	44.4 ± 67.6	n.s.	n.s.	n.s.
GFR mL/min	98.9 ± 24.8	99.7 ± 25.8	98.7± 28.2	n.s.	n.s.	n.s.
Uric acid mg/dl	5.0 ± 1.3	5.2 ± 1.4	5.4 ± 1.5	p<0.001	p<0.001	p<0.001
Blood iron mg/dl	100.2 ± 39.0	98.9 ± 36.5	98.0 ± 39.8	n.s.	n.s.	n.s.

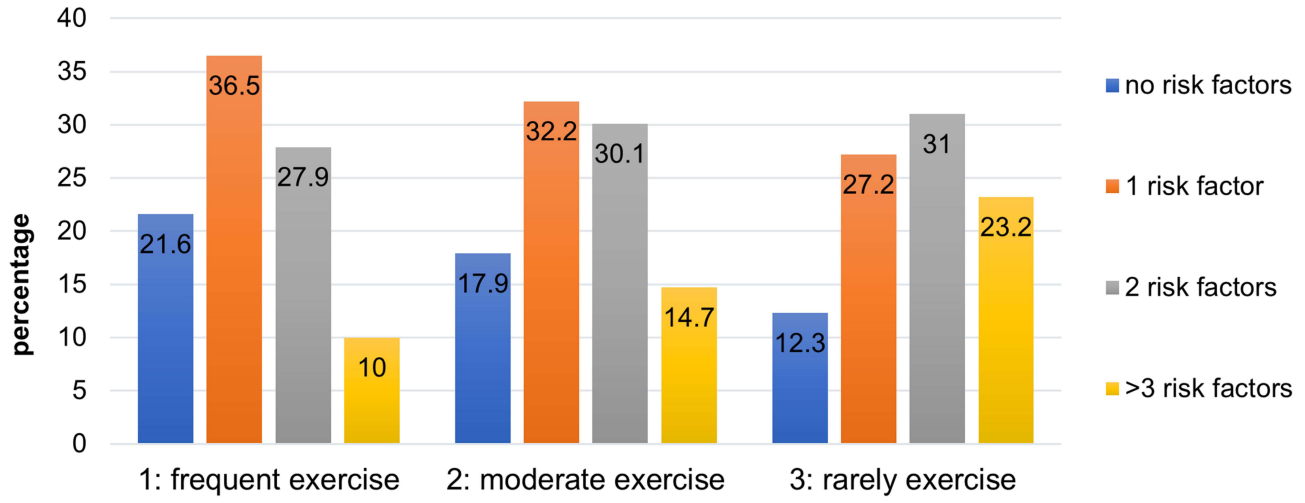


Figure 3 Number of risk factors per person related to the exercise groups.

individuals from low-, middle-, and high-income countries.[12–21]

A limitation is the self-reported level of physical activity which does not always correspond to reality. However, it is extremely difficult to conduct direct measurements of physical activity levels over 5 years in 4602 subjects-especially since our study does not track physical activity, but a variety of other parameters. Direct measurement of physical activity is extremely difficult to achieve in large studies. Nearly all larger intervention studies are generally based on self-reporting. However, we would like to point out that due to the frequent follow-up visits, there is a very close trusting relationship with the study participants. By recording the many parameters listed, we also get very good indications of the overall reliability of the data. In addition, the participants are there voluntarily and are characterized by a high level of motivation. Furthermore, the high number ensures that some inaccurate information does not significantly influence the results. Finally, the consistency of our results with studies that have used direct measures of physical activity levels also suggests that the information provided by participants largely corresponds to actual activity levels. Most of the results described here are not new. From our point of view, the strength of our study is that not individual aspects but, as comprehensively as possible, all relevant factors were investigated simultaneously in a large collective. Thus, psychological/cognitive aspects, dietary behavior, known cardiovascular risk factors, and physical activity were presented simultaneously. Studies that examine all these aspects simultaneously in a larger collective and thus depict the participating individuals in their entirety and also follow them up over several years are costly and thus rare.

After the initial examination, all participants received comprehensive written prevention recommendations

Table 3 Fruit and Meat Consumption and Psychosocial Features in the Three Sports Groups

	Frequent Exercise Group 1	Moderate Exercise Group 2	Rarely Exercise Group 3	Sign. Between 1 vs 2	Sign. Between 1 vs 3	Sign. Between 2 vs 3
High fruit consumption %	64.5	58.5	51.8	p< 0.001	p< 0.001	p< 0.001
High meat consumption %	23.7	30.4	32.7	p< 0.001	p< 0.001	n.s.
High stress %	40.1	47.9	45.4	p< 0.001	p< 0.001	p=0.036
Well-being %	85.7	83.8	81.2	n.s.	p<0.001	n.s.

Note: All 3 groups differ significantly p<0.001 with the numbers of risk factors.

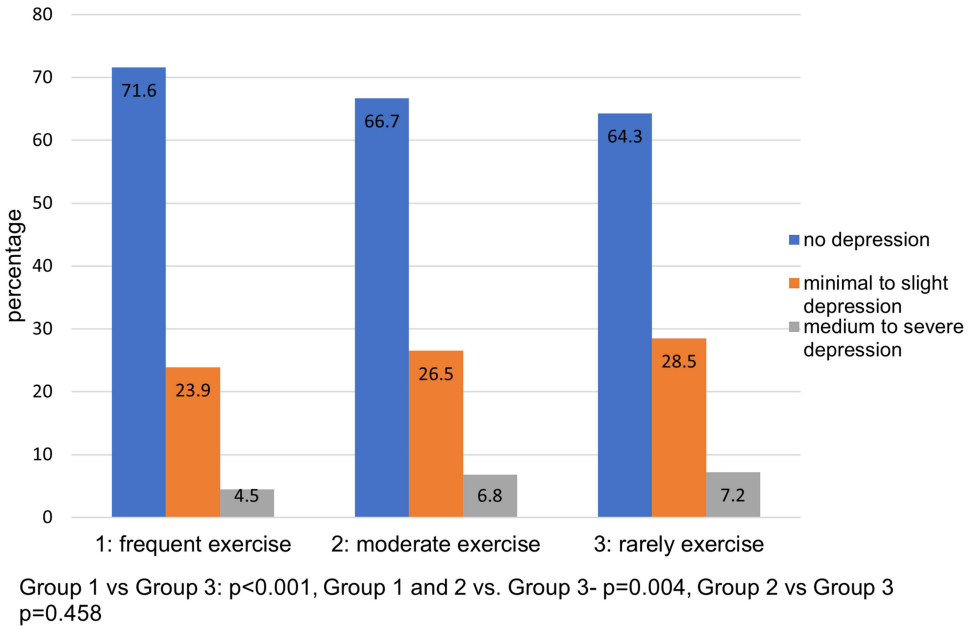


Figure 4 Depression in relation to the different exercise groups.

derived from the individual data and based on the recommendations of the relevant professional societies. In annual controls, the recommendations were checked for their implementation. The long-term observation will show how the investigated parameters change and whether correlations of changes in physical activity with cardiovascular and cerebrovascular events including dementia can be demonstrated.

Despite these established associations, the number of people with adequate physical activity is too low nationally and internationally.[22] Significantly more than half of the population exercises less than medically recommended. Worldwide, the prevalence of physically inactive individuals is 27.5%. This is shown by WHO data from 358 surveys in 168 countries among 1.9 million individuals. Active was defined as at least 150 min per week of moderate activity or 75 of vigorous activity, or a combination of both. Among these, in high-income Western countries, the prevalence of physically inactive individuals was 42.3% and had been steadily increasing over the past 15 years.

Also in this study in northwestern Germany, only 41% practiced sufficient exercise in terms of cardiovascular prevention, 29.8% do not exercise.[7] In addition, 28.8% practiced sports only moderately. This is consistent with statistics in other parts of Germany. Although the number of people who are active in sports has increased, the overall percentage of inactive people is still too high. If the current trend continues, the proclaimed global goal of a 10% relative reduction among poorly active individuals by 2025 will not be achieved.[23]

Of concern is, that according to our data, the group of individuals with risk factors in particular is the least likely to exercise. Hypertension, diabetes mellitus, obesity, dyslipidemia, and nicotine abuse were found significantly more often in the groups that exercised only moderately or not at all. Correspondingly, individuals in the groups with moderate and low levels of exercise also had to take more antihypertensive medications. Nevertheless, blood pressure values were higher in these groups than in the participants with frequent exercise. The significantly lower heart rate among group 1 participants underlines the effectiveness of regular training. Here, the effect is still underestimated because the lower heart rate in the frequent exercise group occurred despite more frequent use of ß-blockers in the moderate and rarely exercise groups. Especially notable in our study was that the group with the least amount of exercise was most likely to have multiple risk factors at the same time. Thus, lack of physical activity primarily affects people who would benefit the most. The low level of exercise among the 30–49 age group is also a cause for concern, as it is precisely in these years that risk factors often manifest themselves. The cause certainly is personal circumstances with starting a family or a business. The slight increase in exercise among the 50–79 age group is encouraging, and the 80–

89 age group has reached the same level of exercise as the 30–39 age group. However, it is also true for older people that especially those with existing risk factors are inactive.

Obviously, therefore, medicine is not succeeding in attracting enough people with risk factors to exercise to even come close to exploiting the preventive potential of physical activity. Nevertheless, blood pressure values were higher in these groups than in the participants with frequent exercise. Especially people who have been physically inactive for many years and have developed various risk factors are difficult to win back for physical activities. It is crucial to find formats for this group that combine sport with fun. Cooperation with training specialists can be additionally helpful in this regard.

One possibility is shown by the 3F study: "Fit and Fun with Football". The idea was to use the popularity of football. For this purpose, a project was developed for older participants with cardiovascular risk factors who had been inactive for many years. The project was designed to improve the risk factors by playing football in a fun way, using rules and forms of training that avoid injuries. It was important to start very carefully and to avoid false ambition in this older risk group. The results show a significant reduction in blood pressure, antihypertensive medication and weight compared to a control group.[24,25] There was no correlation between training times and the significantly improved endpoints.

In any case, the training time necessary for prevention is intensively discussed. Three to five times a week of 30–45 min. or 75 min. of intensive or 150 min. of moderate training is considered ideal, although this training intensity was achieved in the frequent exercise group, and sometimes exceeded. However, many different studies indicate that even significantly lower training times lead to positive health effects and significantly reduce the event rate. This is especially true for people with risk factors and when they start exercising after a long break.[12,16,26–28]

Exercise can have a beneficial effect on negative stress, depression and overall quality of life. This was also shown in our study, where the group with frequent exercise showed a reduction in stress and depression as well as an increase in well-being. However, these certainly existing benefits are difficult to prove in individual cases. The reason for this is additional stress factors outside of sport that can negatively influence the beneficial effect of sport, such as family, job and financial stress.

Other studies also show that sport participation is associated with positive effects on life satisfaction, cognitive functions and psychological well-being.[29–32] Willis et al showed that physical fitness in middle age is associated with a lower risk of later depression and cardiovascular mortality.[33]

The Corona Crisis with the lockdowns had a significant negative impact on the mental health of the population. A survey of participants in this ELITE study showed a worsening of the medical situation, especially in the case of pre-existing depressive symptoms, while people who also exercised sufficiently during this time reported favourable effects.[34]

Conclusion

In summary, exercise leads to improved physical health, greater life satisfaction, improved cognitive functioning and psychological well-being. Unfortunately, it does not reach the people who would benefit most. Conversely, physical inactivity appears to be associated with the development of mental disorders. In addition, team sports can have a favourable effect on two other factors that are considered to trigger mental crises: social exclusion and the feeling of being isolated and on one's own.

Ethics Approval and Consent to Participate

All subjects gave their informed consent for inclusion before they participated in the study. The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the Ethics Committee of University of Göttingen (34/6/14).

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Disclosure

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