Level of Physical Activity and Its Associations with Lung Function of Medical Students

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Abstract

Lung function is a well-established predictor of mortality and is used routinely in general health assessment. The objective of this study is to elaborate the importance of physical activity on lung function, focusing on daily activity as the domain parameter. Forty eligible medical students were interviewed for study parameters, answered GPAQ and underwent spirometry measurement. All data interpreted using an established method based on Pneumobile Project Indonesia. Comparison between each level of physical activity (LPA) was assessed with Kruskall-Wallis test, followed by Dunn's multiple comparison post hoc test.The number of medical student with LPA and lung function were almost similiar in low and moderate plus high groups. The FVC in low, moderate, and high LPA are: 105.4±2.2% (n=20), 112.6±2.2% (n=17), and 118±6.3% (n=3), respectively. The FEV1 in low LPA group is 109.2±2.4%, moderate 113.7±2.4%, and high 122±7.2%.Students with higher LPA are associated with higher FVC, FEV1, and spent less time on sedentary activities weekly.
Keywords: *level of physical activity, association, lung function, medical students*

Tingkat Aktivitas Fisik dan Hubungannya dengan Fungsi Paru Mahasiswa Fakultas Kedoktereran

Abstrak

Fungsi paru adalah prediktor kematian yang terbukti dan digunakan secara rutin dalam penilaian kesehatan umum. Penelitian ini bertujuan untuk mempelajari pentingnya aktivitas fisik untuk fungsi paru, dengan memfokuskan kegiatan sehari-hari sebagai parameter pengukur. Empat puluh mahasiswa kedokteran yang memenuhi syarat diwawancarai untuk parameter studi, menjawab GPAQ dan menjalani pengukuran spirometri. Semua data diinterpretasikan berdasarkan hasil Proyek Pneumobile Indonesia. Perbandingan antara setiap tingkat aktivitas fisik dinilai dengan uji Kruskall-Wallis, diikuti dengan uji Dunn's multiple comparison post hoc test.Jumlah mahasiswa kedokteran yang mempunyai nilai aktivitas fisik dan fungsi paru nyaris seimbang antara nilai rendah dibandingkan dengan sedang dan tinggi. Nilai FVC pada mahasiswa dengan tingkat aktivitas fisik rendah, sedang, dan tinggi adalah 105,4±2,2% (n=20), 112,6±2,2% (n=17), dan 118±6,3% (n=3). Nilai FEV1 pada kelompok dengan aktivitas fisik rendah: 109,2±2,4%, sedang 113,7±2,4%, dan tinggi 122±7,2%. Mahasiswa dengan tingkat aktivitas yang lebih tinggi mempunyai nilai FVC dan FEV1 yang lebih tinggi dan menghabiskan lebih sedikit waktu dalam melakukan kegiatan yang rutin dan tetap.
Kata kunci: *tingkatan aktivitas fisik, asosiasi, fungsi paru, mahasiswa kedokteran*

Introduction

Lung function is well-established predictor of mortality described as early as four decades ago.[1] Lung function is a long-term predictor for overall survival rates in both genders and could be used as a tool in general health assessment.[2] Poor lung function is often characterized by low forced vital capacity (FVC) and forced expiratory volume in one second (FEV1), where this association is observable in both in short[3] and longterm[4] cohort studies. Several mechanisms that affect lung function have been proposed, including physical activity,[5] smoking, obesity, lung diseases such as chronic obstructive pulmonary disease (COPD), sex, and race.[6] However, the relative importance of individual mechanism remains unclear. Only several investigators have been able to use a comprehensive range of explanatory risk factors within a single methodological setup. In regards to the study of lung function, many investigators put great interest to physical activity as an influencing factor. Since physical activity is one of the most easily modifiable risk factor across a wide range of age group. Additionally, regiments of physical activity for therapeutic purposes can be implemented for people with comorbid diseases (e.g. hypertension, osteoarthritis).

The importance of physical activity for health is well-known, but little is known about the direct influence of exercise on pulmonary function. Investigations have studied the association between improved lung function with physical activity by means of reducing body weight,[7] musculoskeletal strengthening,[8] and improving the cardiovascular system.[9] The health-promoting effects of regular physical activity are well-established.[10] Despite the knowledge of its health-enhancing effects, engagement in regular physical activity can be daunting for people with deskbound lifestyle, such as office worker or medical student. Moreover, few studies have focused on domain-specific activities performed during daily routines. Specifically the analyses of the common domains (e.g. work, transportation, recreational, leisure time) of physical activity are sparse.[11] Information on the effects of physical activity for the lung function is crucial, especially for people who are incapable or not willing to engage in regular exercise. The importance of incorporating regular activities into daily routines has been averred by experts for its protective effect from premature morbidity and mortality, which is related to lung function.[12] Furthermore, people do physical activity at different levels intensity (e.g. low, moderate, or high intensity). Most studies do not investigate its relationship with lung function. Thus, the association between different levels of physical activity with lung function remains uncertain. It is the objective of this study to elucidate this relationship. To our knowledge no such study has been conducted in the younger population; this is the first study that attempts to answer the question.

Methods

This is a preliminary cross-sectional study; there was no literature or prior study conducted on Indonesian population that has described lung function and its relation to different levels of physical activity. Thus sample estimation for a non-preliminary study cannot be conducted. Consequently, this study used convenience-sampling method that aims to recruit at least 30 subjects. The study population of this study is medical student from Universitas Indonesia. The inclusion criteria were healthy male or female subjects, willing, and are capable of participating in this research. Subjects with recent infection, exacerbation of asthma, and surgery were excluded from the study. Data collection was conducted in the Department of Physiology on February until March 2010. Ethics and research approval was obtained from the Faculty of Medicine and the Department of Physiology Universitas Indonesia, January 2010.

Spirometry was conducted by using procedural standard from Persahabatan Hospital and Global Initiative for Chronic Obstructive Lung Disease (GOLD) standards.[13] Spirometry measurements were taken using a digital-portable spirometer (Koko Legend, Ferraris Respiratory Inc., USA), conducted by trained investigators. Lung function parameters used are the FVC, FEV1, and Ratio of FEV1 to FVC (FEV1/FVC or FEV1%). This is in concordance with the guideline used in Persahabatan Hospital based on the consensus of

The Indonesian Society of Respirology (Perhimpunan Dokter Paru Indonesia). Spirometry measurements were conducted at least three times until reproducible measurements were obtained, where each value is equal-to or less-than 5% or 100 mL difference between each other. Accordingly, every subject was interviewed based on the Global Physical Activity Questionnaire version 2 (GPAQ2) prior to spirometry to determine their level of physical activity.[14] The three domain measured are activity at work (including school hours for students), travel to and from places, and recreational activities measured in Metabolic Equivalent/MET (Table 1). Types of domain are listed in the left column with its corresponding metabolic equivalent (MET) value based on intensity listed in the right column.

Table 1. Estimated MET Value with Each Domain of Physical Activity

Domain	METS value
Work	- Moderate MET value = 4.0 - Vigorous MET value = 8.0
Transport	Cycling and walking MET value = 4.0
Recreation	- Moderate MET value = 4.0 - Vigorous MET value = 8.0

MET is the ratio of the work metabolic rate to the resting metabolic rate, defined as 1 kcal/kg/hour and is equivalent to the energy cost of sitting quietly. A MET is also defined as oxygen uptake in milliliter (mL)/kg/minute with one MET equal to the oxygen cost of sitting quietly, around 3.5 mL/kg/minute. The investigator is allowed to give verbal guidance to respondents regarding the questions, however limited. The respondent's answers were then calculated based on the formulae provided to determine the Table 2.

Table 2. GPAQ2 Formulae Used for LPA Calculations

Level of Physical Activity	Physical Activity Cut-off Value
High	IF: (P2 + P11) ≥3 days AND Total physical activity MET minutes per week is ≥1500
	OR
	IF: (P2 + P5 + P8 + P11 + P14) ≥7 days AND total physical activity MET minutes per week is ≥3000
Moderate	IF: (P2 + P11) ≥3 days AND ((P2*P3) + (P11*P12)) ≥60 minutes
	OR
	IF: (P5 + P8 + P14) ≥5 days AND ((P5*P6) + (P8*P9) + (P14*P15) ≥150 minutes
	OR
	IF: (P2 + P5 + P8 + P11 + P14) ≥5 days AND Total physical activity MET minutes per week ≥600
Low	IF: the value does not reach the criteria for either high or moderate levels of physical activity

MET: Metabolic Equivalent of Task

GPAQ2: Global Physical Activity Questionnaire version 2

Three different LPA listed in the left column. The right column contains the formulae used for the determination of physical activity level. There are two formulae that can be used for high level and three for moderate LPA, each separated by **OR**. There are a total of 16 questions in GPAQ2; questions P1 – P6 covers activity at work, P7 – P9 covers travelling, P10 – P15 covers recreational activities, and P16 covers sedentary behavior.

All data interpreted using an established method based on Pneumobile Project Indonesia,[15] and analyzed using GraphPad Prism 5 software (GraphPad Software, San Diego, CA, USA). Data were tested for normality using D'Agostina and Pearson omnibus test. Comparison between each level of physical activity (low, moderate, and high) was assessed with Kruskall-Wallis test, followed by Dunn's multiple comparison post hoc test. P value less than 0.05 are considered to be statistically significant. Data from the experiment were presented as mean ± standard error of the mean (SEM).

Results

This study collected data from 40 subjects; 22 male and 18 female. There are 20 subjects with low, 17 with moderate, and 3 with high LPA. The average age of subjects in every group was 21 years old, ranging from 18 to 24 years old. The average BMI were 21.2 (16.7-29.2), 22.3 (19.2-34.1), and 22.3 (21.8-25.5) in low, moderate, and high LPA group respectively. Males constitute about half of the subjects in each LPA groups, with the least number in low LPA. The majority of female subjects (61%) were engaged in low physical activity. There are two active cigarette smokers; one in low and one in moderate LPA group. One subjects had a history of bronchitis and asthma in low LPA, six subjects with bronchial asthma in the moderate LPA group. None of the subjects were involved in vigorous-intensity work, while two subjects were engaged in moderate-intensity work in the moderate LPA group. Most the subjects who participated in sports belongs in the moderate and high LPA group.

Level of Physical Activity

All participants have successfully answered the GPAQ. Fifty percent of the subjects had low physical activity level (n=20), n=17 subjects had moderate LPA, while the rest (n=3) were engaged in high LPA. All subjects acquired some level of MET weekly through traveling by means of walking or cycling (GPAQ question P7, P8, and

P9). Most students with moderate and high level of LPA acquire larger MET value by engaging in longer periods of moderate-intensity (i.e. brisk walking, cycling, swimming) or vigorous-intensity activity (i.e. basketball, football, fitness training). The average sedentary period across all three LPA groups bears no significant differences, which are 663±224 minutes for low LPA, 699±226 minutes for moderate LPA, and 420 ± 159 minutes for high LPA (Table 3).

Table 3. Level of Physical Activity Among Subjects

Level of Physical Activity	Male (n=22)	Female (n=18)	Total (n=40)
Low	9	11	20
Moderate	11	6	17
High	2	1	3

Lung Function

Spirometry was carried out consistently in all subjects. All participants were capable of following the instructions given and required less than 8 attempts of spirometry maneuvers in producing 3 collectible measurements. The highest average lung function values are observed in the high LPA group, followed by moderate and low LPA group (Table 4).

Table 4. The Average Lung Function Values of Every LPA Group

Lung Function Values	Low LPA (n=20)	Moderate LPA (n=17)	High LPA (n=3)	P <0.05
FVC/FVC prediction	105.4 ± 2.2 %	112.6 ± 2.2 %	118 ± 6.3 %	Low vs. moderate
FEV1/FEV1 prediction	109.2 ± 2.4 %	113.7 ± 2.4 %	122 ± 7.2 %	-
FEV1/FVC (FEV1%)	92.7 ± 0.9 %	90.1 ± 1.5 %	92.4 ± 3.8 %	-

FVC: forced vital capacity, FEV1: forced expiratory volume in one second, FEV1/FVC (FEV1%): ratio of FEV1/FVC
Data of lung function values are shown as mean ± SEM.

The low and moderate LPA group has sufficient number of subjects for normality test, using D'Agostina and Pearson omnibus tests. However, the number of subjects in the high LPA group was not sufficient for normality test. Consequently non-parametric statistical analysis (Kruskall-Wallis) was used to analyze the lung function values of the three groups, followed by Dunn's multiple comparison tests.

Forced Vital Capacity (FVC)

The following figure shows the average FVC of each subjects divided by the predicted normal values within each LPA group (Figure 1). Presented data are the average value of the subject's FVC divided by their predicted normal value shown in percentage. Low Vs Moderate: $p<0.03$; Low Vs High & Moderate Vs High: $p<0.05$. Data are shown as mean ± SEM; Low: n=20, moderate: n=17, and high: n=3. *$p<0.05$

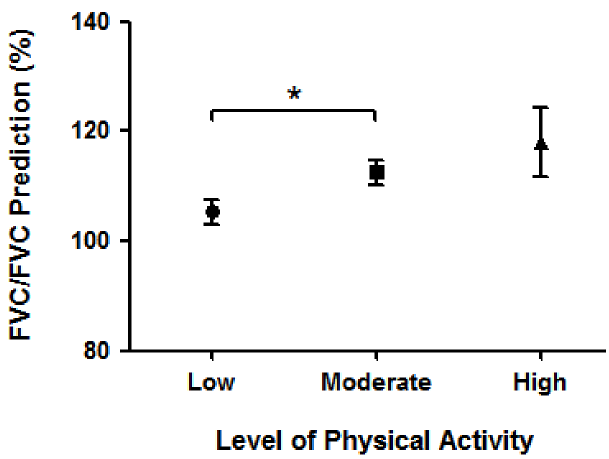

Figure 1. Comparison of FVC/FVC Prediction Value between Each LPA

Forced Expiratory Volume in One Second (FEV1)

The FEV value is similarly analyzed like FVC; by dividing FVC with normal prediction value (Figure 2). Presented data are the average value of the subject's FEV1 divided by their predicted normal value shown in percentage. Low Vs Moderate; Low Vs High; & Moderate Vs High p=<0.05. Data are in mean ± SEM; Low: n = 20, moderate: n = 17, and high: n = 3.

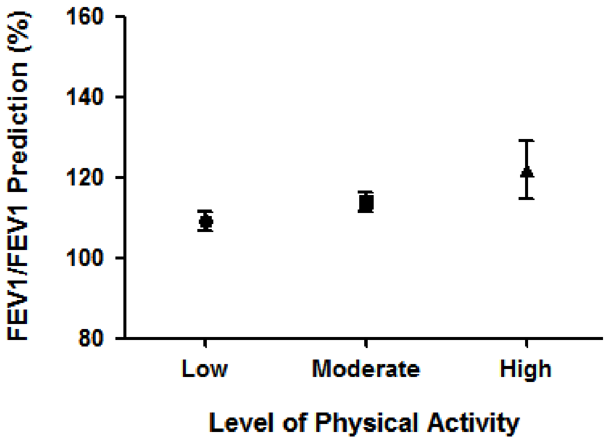

Figure 2. Comparison of FEV1/FEV1 Prediction Value between Each LPA

FEV1 to FVC Ratio (FEV1%)

All subjects have normal FEV1% value (>75%) with similar average amongst all groups (Figure 3). The x-axis shows the ratio of FEV1 to FVC (FEV1%) of male and female subjects within each LPA groups shown in percentage value. Low vs moderate; low vs high; & moderate vs high p=<0.05. Data are shown as mean ± SEM; Low: n = 20, moderate: n = 17, and high: n = 3.

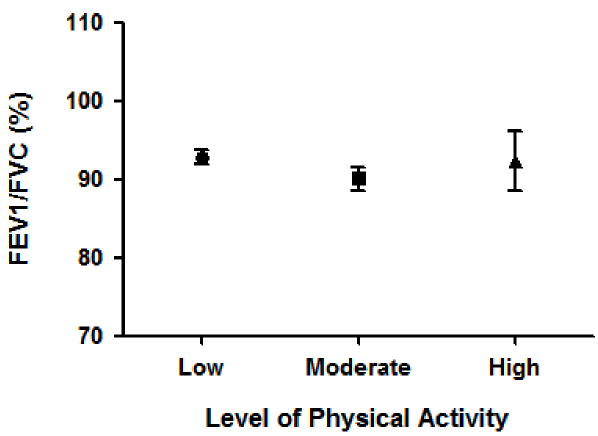

Figure 3. Comparison of FEV1/FVC Value between Each LPA

Discussion

We found that higher LPA were associated with higher FVC and FEV1. Additionally, lower LPA is associated with increased time spent on sedentary activities. Out of the 40 medical students who participated in this study, 50% of them were engaged in low LPA and only about 8% of them were regarded to have high LPA. These findings are in concordance with our proposed hypothesis; subjects with higher physical activity possess larger FVC and FEV1 value. This study has provided valuable insights on the effect of physical activity on the lung function of subjects in FKUI and its relationship with other influencing factors.

Level of Physical Activity and Characteristics of Subjects

All subjects who participated in study has successfully undergone standardized spirometry measurement without predicaments and completed all research-related questions with their LPA determined. The subjects are distributed into three different LPA group with similar age average, BMI average, number of male and female. Smokers (n=2), students with history of lung disease (n=8), overweight (n=8), and class I obese (n=1) subjects were included in this study. According to the literature smoking,[16] obesity,[17] and history of lung diseases,[18] were associated to the pulmonary system with deleterious effects. However, considering the low number of samples with each factor, its relationship with the LPA cannot be determined and should be the scope of a separate study. None of the participants of this study work with vigorous-intensity activity; which is regarded only if they cause a large increase in breathing and/or heart rate. One probable reason for this is because all of the subjects are medical students who were primarily engaged in long-hours of academic activities.[19] Only two subjects were engaged in moderate-intensity work, by which such activity was undertaken outside their academic schedule. Their American counterparts mitigate this problem by engaging in a very different lifestyle, where subjects and physicians are doing more physical activity than the general US adult population.[20]

Continuous walking or cycling for more than 10 minutes contributes to 4 MET per minute and were undertaken by subjects who lived in the vicinity of the University. There are more subjects in the moderate (88% n=15) and high (67% n=2) LPA group that were engaged in such activity. This shows the importance of modes of transportation (i.e. longer walking, brisk-walking) on contributing to higher level of MET. Similarly, observations of British school children conducted by Owen CG et al. showed that active travel is associated with higher levels of objectively measured physical activity.[21]

How recreational sports activities affect the LPA is clearly reflected in recreation domain. There are more subjects who do sports in the moderate (59% n=10) and high (67% and 33%) LPA group compared to low LPA group (20%-25%). Most subjects that do vigorous-intensity physical activity usually involve team sports such as basketball and football, where it contributes to 8 MET points for every minute of activity. Thus, engaging in vigorous-intensity exercise is detrimental for the LPA classification, which was similarly reported by Mehrota et al[22] and in a Greek population study by Doherty et al,[23] where both water and land-based sport athletes had high lung function values.

It can be observed that BMI is not significantly affected by the degree of exercise; higher BMI average is found in the moderate and high LPA groups. However, this marginal difference is most likely to be caused by the small number of sample; creating a non-representative BMI of the true population of each group. Subjects with lower LPA are also associated with higher sedentary activities, including time spent on sitting or reclining. Modifying or increasing the LPA in people with sedentary occupation, such as medical student or a typical office worker can be particularly challenging. This is because their main daily activities involve long-hours of sitting and other sedentary behavior. Similar phenomenon was also observed in a Polish study conducted by Biernat E et al.[24] These findings suggest associations of sedentary lifestyle with decreased lung function, which in turn affects the overall health of an individual. However, the inverse relationship is yet to be studied. On the basis of these findings, non-exercise activities such as housework and modes of transportation should be fully integrated into daily routines as they were found to contribute to the MET and LPA. A widely suggested way to promote higher LPA is by increasing other domains of daily activities such as transportation and recreational activities.[12]

Lung Function

Regardless to the physiologic differences of male and female lung volume, both sexes were calculated within the same group, as the calculation of lung volume is based on the predicted normal value. All the FVC of the subjects were above 80%. An increasing trend of FVC is observable from the low, moderate and high LPA continuously. Subjects with low LPA have the lowest FVC (105.4±2.2% n=20), followed by FVC in the moderate LPA group (112.6±2.2% n=17), and high LPA (118±6.3% n=3). The difference of mean FVC between low versus (vs) high and moderate vs high was not statistically significant ($p<0.05$). Kruskall-Wallis analysis of showed a significant interaction between the low and LPA group.

Since the FVC value in low and moderate LPA group passed the D'Agostino and Pearson omnibus normality tests; we further analyzed the difference using unpaired t-test, yielding $p=0.03$.The FEV value also shows similar trend to FVC: lowest FEV in the low LPA (109.2±2.4% n=20) group, greater FEV1 in moderate LPA group (113.7±2.4% n=17), and highest in students (122±7.2% n=3) with high LPA. These findings demonstrate the association of higher level of physical activity with increased lung capacities. It is similar to a study conducted by Holmen et al,[16] where the largest FVC and FEV1 were measured in subjects with higher LPA. Such disparity of approximately one-tenth of the lung capacities between the two distinct groups may prove to be clinically not significant. Since the variability between individual values range around 10% for FVC in the low is 100-110%, moderate 107-117%, and high 91-145%. The determination of on the clinical significance of such difference will require a more rigorous test and clinical judgment, which is beyond the scope of this study. Another method to study this relationship is by conducting a longitudinal study that can determine the effect of reduced lung capacities over time.

All subjects hd normal FEV1% value (>75%) with similar average amongst all groups. The FEV1/FVC (FEV1%) displayed a different trend in values: the lowest mean FEV1% belongs to the moderate LPA group (90.1±1.5% n=17), while the low (92.7±0.9% n=20) and high LPA (92.4±3.8% n=3) shared a similar FEV1. This is probably because FEV1% is a sensitive measurement for obstructive lung disease,[6] which our subjects did not experience during spirometry measurement. Wider SEM value is observable in the high LPA group, as a result of smaller number of subject in the group (n= 3). Whether physical exercise leads to better lung capacity, or if there is a significant difference of lung capacities between the low, moderate, and high level of physical activities cannot be proven in this study.

Study Limitations and Future Directions

The design of this study; cross-sectional does not allow the cause-effect observation of physical activity on lung function. Thus, this study will only provide comparative assessment. Another major limitation of the cross-sectional study design is the limited inability to minimize sampling error; subjects with higher level of physical activity or more involved in sports may have better lung function in the first place. To overcome the limitations of our current study, longitudinal or experimental study may serve as a better study design to illuminate the association between physical exercise and lung function by enabling the cause and effect relationship. To our knowledge no such study has been conducted in the Indonesian population.

Spirometry is the gold-standard diagnostic measurement for lung function. However there are limitations from the use of such intricate instruments. The instrument requires regular technical maintenance and constant calibration. Competent and experience operator are needed to produce valid measurements. These technical hindrances are some of the drawbacks rendering the spirometry test unable to be conducted outside capable institutions. To minimize the measurement error in spirometry, operators should acquire sufficient training and practice. Limiting the number of operator can also reduce variability of measurements. Should future studies be conducted in a longitudinal design, the operator should also be blinded to eliminate measurement bias.

Our data on the subjects's physical activity were self-reported through the GPAQ questionnaire. Thus, reporting bias cannot be fully avoided. Another limitation is that physical activity was recorded once where it might not be representative of the respondents' true activity routines. Follow-up data on physical activity were not conducted on an individual level; therefore, we assume that physical activity patterns remain fairly stable over time. Furthermore, participants often required verbal guidance by the investigator in answering the questionnaire. This opens the possibility for variability, such as the participant interpretation. Limited changes can be done to eliminate recall bias in an interview or questionnaire-based data. To minimize this, future investigator should always use validated and standardized questionnaires; which to our knowledge no such questionnaire has been devised for the Indonesian population. Categorization of LPA into low, moderate, and vigorous physical activity may have led to stringent or misclassification. That is why future studies should explore the use of a more accurate and detailed measurement for the subjects's physical activity in this particular population.

Longitudinal study should be able to provide a more accurate analysis on the effect of physical activity on lung function. With better understanding on the association of physical activity and lung function, preventive or therapeutic measures can be applied as health promotion and preservation. Such intervention should be targeted on the improvisation of daily activities on attaining higher physical activity level. This is particularly important for people with relatively sedentary lifestyle that are incapable of engaging in routine exercises or sporting activities.

Conclusion

Students with higher levels of physical activity were associated with higher FVC and FEV1. Half of the subjects who participated in this study had low physical activity level, 40% with moderate, and only minority with high physical activity level. The average FVC fractions of subjects in FKUI with low, moderate, and high level of physical activity are: 105.4±2.2%, 112.6±2.2%, and 118±6.3%, respectively. Meanwhile the FEV1 fraction in low LPA group is 109.2±2.4%, moderate 113.7±2.4%, and high 122±7.2%. To overcome the limitations of our current study, longitudinal or experimental study may serve as a better study design to study the association between physical exercise and lung function by enabling the cause and effect relationship.

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