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What is the Most Important Percentage of Pressure in Inspiratory Muscle Warm-Up Exercises for Children?[1]

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ORIJINAL ARTICLE

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Abstract

It has been observed that inspiratory muscle warm-up exercises with a device (IMW-D), which has started to take place in general warm-up in recent years, contribute to performance in a positive fashion. In the literature, IMW-Ds are usually performed with 40% of maximum inspiratory pressure (MIP). There is not a single study explaining or determining the best percentage of MIP in both acute and chronic studies on IMW-Ds in the literature. Therefore, in this study, it was aimed to determine the most important pressure percentage to improve respiratory parameters in IMW-Ds. A total of 40 athletes with licenses in a federation between the ages of 12-14 participated in the study. Participants underwent IMW-D with a powerbreathe plus respiratory exercise device at 15%, 30%, 40%, 45%, 50% and 60% of the MIP on different days, and immediately following these exercises were performed with a spirometer, respiratory parameters were measured as (FVC, FEV1, PEF). Kruskal Wallis H test was used in order to determine the difference between measurements. As a result of statistical analysis, it was found that while there was significant difference in PEF values between 15% and 40%, 45% of MIP; and the highest improvement was 45%, 50% and 60% of MIP in FVC, FEV1 and PEF values. It can be suggested that sedentary people and athletes who want to improve their respiratory parameters can also train with 45%, 50% and 60% of MIP without depending on 40% of the MIP applied only as given in the literature for a higher improvement in their IMW-D.

Keywords: Inspiratory muscle warm-up, Respiration, Powerbreathe, Maximum inspiratory pressure

Çocuklar İçin İnspiratuar Kası Isınma Egzersizlerinde En Önemli Basınç Yüzdesi Kaçtır?

Öz

Son yıllarda genel ısınma içerisinde yer almaya başlayan aletli inspiratuar kası ısınma egzersizlerinin (IKI-A) performansa olumlu yönde katkı sağladığı görülmüştür. Literatürde IKI-A'leri genellikle maksimal inspiratuar basıncın (MIP) %40 ile yapılmaktadır. IKI-A'leri ile ilgili hem akut hem de kronik çalışmalarda en iyi MIP yüzdesinin kaç olduğu açıklayan ya da belirleyen bir çalışmaya literatürde rastlanmamıştır. Bu düşünceler ile yapılan çalışmada IKI-A'lerinde solunum parametrelerini geliştirmek için en önemli basınç yüzdesinin belirlenmesi amaçlanmıştır. Çalışmaya 12-14 yaşları arasında toplam 40 lisanslı sporcu katılmıştır. Katılımcılara farklı günlerde MIP'in %15, %30, %40, %45, %50 ve %60'ında powerbreathe plus solunum egzersiz cihazı ile IKI-A yaptırılmış ve bu egzersizlerin hemen ardından spirometre ile solunum parametreleri (FVC, FEV1, PEF) ölçülmüştür. Ölçümler arası farkı belirlemede Kruskal Wallis H testi kullanılmıştır. İstatistik analiz sonucunda; MIP'in %15'ine göre %30, %40 %45, %50, %60'da yapılan IKI-A'nın solunum parametrelerini daha fazla geliştirdiği, ayrıca en yüksek gelişimin MIP'in %45, %50 ve %60'ın da olduğu görülmüştür. Solunum parametrelerini geliştirmek isteyen sedanterlerin ve sporcuların IKI-A'lerinde daha yüksek bir gelişim için sadece literatürde uygulanan MIP'in %40'ına bağlı kalmadan MIP'in %45, %50 ve %60'ı ile de çalışabilecekleri söylenebilir.

Anahtar kelimeler: İnspiratuar kas ısınma, Solunum, Powerbreathe, Maksimal inspiratuar basınç

[1] Bu çalışma 11 - 14 Kasım tarihleri arasında düzenlenen 19. Uluslararası Spor Bilimleri Kongresinde sözel bildiri olarak sunulmuştur.

Introduction

The amount of feeling of shortness of breath during exercise is directly proportional to the maximum dynamic strength used by the inspiratory muscles and the magnitude of the inspiratory muscle strength output (Tong et al., 2004). It has been reported that improving the maximum dynamic inspiratory muscle function can reduce the feeling of shortness of breath during exercise (Romer et al., 2002a; Romer et al., 2002b). Therefore, it has been said that adding inspiratory muscle warm-up to the general whole-body warm-up protocol can improve maximum dynamic inspiratory muscle function (Tong and Fu, 2006). In a study conducted by Voliantes et al., (2001a) it was stated that the ventilation activity applied to the inspiratory muscle could increase the force-generating capacity of the muscle, which would have a positive effect on performance. On the contrary, fatigue of the inspiratory muscles causes a decrease in performance (Inbar et al., 2000; Johnson et al., 1993). One of the mechanisms that causes inspiratory muscle fatigue and limits the exercise tolerance of the inspiratory muscle is the metaboreflex, which reduces blood flow and limits locomotor muscle function (Wüthrich et al., 2015). Metaboreflex respiratory muscles restrict blood flow to the extremities of the body when they are tired. In a study, it was reported that improved inspiratory muscle function following the inspiratory muscle warm-up protocol reduced the sensation of dyspnea and delayed the activation of respiratory muscle metaboreflexes (Cheng et al., 2013). Therefore, in order to delay the effect of respiratory muscle fatigue, IMW-D can be used both acutely (Arend et al., 2016; Özdal, 2016; Volianitis et al., 2001a) and chronic (Cheng et al., 2013; Tong et al., 2010; Turner et al., 2013) effects primarily on chronic obstructive pulmonary patients (Liu et al., 2020) and then on athletes (Cheng et al., 2013; Tong et al., 2010; Turner et al., 2013) was applied. However, the effects of acutely applied inspiratory muscle exercise on athletic performance have received less attention, and a limited number of studies have investigated the effects of IMW-D on MIP and athletic performance (Arend et al., 2015; Brown et al., 2014; Johnson et al., 2014; Lin et al., 2007; Tong and Fu, 2006; Volianitis et al., 2001a). In a review, it was stated that including inspiratory muscle warm-up in training programs is an effective method to achieve positive results in athletic performance (Illi et al., 2012). In a study, it was observed that IMW-D applied in addition to a rowing-specific warm-up protocol improved the performance of 6-minute all-out rowing and partially reduced the feeling of shortness of breath (Volianitis et al., 2001b).

In the current literature, a relationship has been found between the changes in the MIP percentages used to determine the exercise intensity of IMW-D and the changes in exercise performance following inspiratory muscle warm-up (Griffiths and McConnell, 2007; Lomax et al., 2011). In the literature, although the factors affecting the MIP value are known (participant characteristics, effort and test performance during the test, age, gender, height, weight, fitness level, smoking, etc.), no clear information has been given about the MIP values to be applied (Evans and

Whitelaw, 2009; Costa et al., 2010; Carpenter et al., 1999; Chen and Kua, 1989). The intensity of IMW-D was determined as 40% of MIP in several acute (Özdal, 2016; Çelik et al., 2021; Cheng et al., 2020) and chronic studies (Cheng et al., 2013; Wetter at al., 1999; Yılmaz and Özdal, 2019). In addition, an exercise protocol consisting of 30 inspirations in two sets applied was performed with 40% of the MIP in these studies. In contrast, moderate to high intensities were used for general whole-body warm-up just before sports activities to achieve better results in athletic performance (Zois et al., 2013; Zois et al., 2015). It was stated that since respiratory muscles, which are regarded as skeletal muscles due to their morphological and functional characteristics, gave the same responses to exercise as skeletal muscles (Kraemer et al., 2002), a higher intensity inspiratory muscle warm-up would prepare the respiratory system better (Arend et al., 2016).

In the light of this information, the hypothesis of the study is that IMW-D performed at high MIP will provide a higher improvement in respiratory parameters. In this study, it will be investigated whether MIP values other than 40% of the MIP used in IMW-D in the vast majority of the literature will give similar results or whether they will provide higher improvement in the respirtory parameters and it is beleived that the study will contribute to the gap in the literature.

Materials and Methods

Ethics committee approval was obtained for the study from the Niğde Ömer Halisdemir University Non-Interventional Clinical Research Ethics Committee with the date of 06.12.2021 and the decision number 2021/85. This study was conducted in accordance with the Principles of the Declaration of Helsinki. After explaining the purpose of the study and the procedures to be done to the participants, an informed consent form was signed.

Research Group

A total of 40 athletes with licenses in a federation who constitute the sample of the study are healthy lisensed athletes between the ages of 12-14 (age 12.97±.80, height 155.32±6.56, weight 48.80±8, MIP 75.48±19.01), who regularly attends training in various branches four days a week, does not have cardiopulmonary disease and has normal lung function. The inclusion criteria of the participants are; individuals who are non-smokers and have no lung disease (Asthma COPD, etc.) as well as those training regularly.

Research Design

MIP was calculated to determine the exercise load of the participants before starting the IMW-D protocol. Then, on separate days for each participant, 2 sets of 30 repetitions with MIP 15%, MIP 30%, MIP 40%, MIP 45%, MIP 50% and MIP 60% respectively, and 2 minutes between sets, resting and IMW-D protocol was applied (Figure 1). Spirometric measurement was performed to determine dynamic lung capacity immediately after IMW-D was applied. The IMW-D protocol at each different MIP value was applied at the same time of the day with an interval of 24 hours. On the first day when the MIP value was determined, each participant was taught to use the respiratory muscle exercise device separately, and the study started after it was observed that all participants were performing the IMW-D properly.

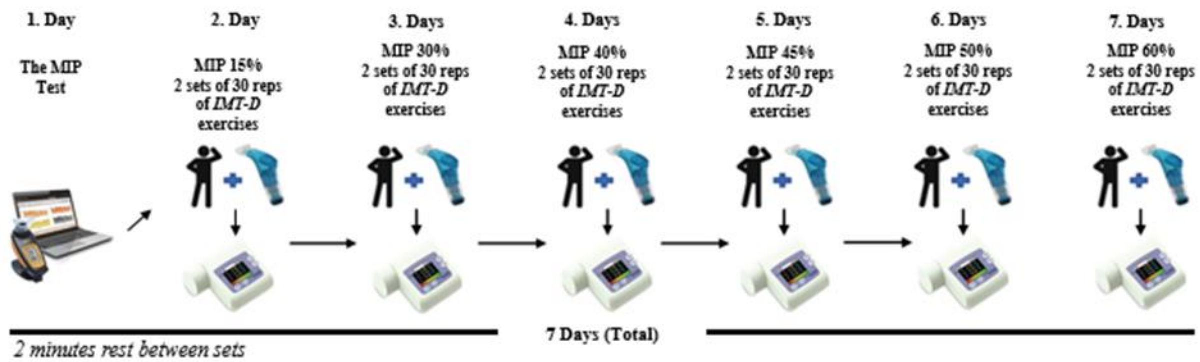

Figure 1. Inspiratory Muscle Warm-up Exercise Protocol

The Inspiratory Muscle Warm-up Exercise with a Device

Before starting IMW-D, participants' MIPs were measured with a powerbreathe K5 respiratory exercise to determine exercise load (Powerbreathe inspiratory muscle trainer, Ironman K5, HaB Ltd., UK). In the measurement, 30 ventilations were performed for twice and the best value was recorded. After determining the maximal inspiratory pressure (MIP - cmH2O), individual exercise load was adjusted with 15%, 30%, 40%, 45%, 50% and 60% of this pressure. Next, the participants performed IMW-D using the plus (blue) model of the powerbreathe plus inspiratory exercise device, which has progressive pressure training and a mechanically adjustable load adjustment range of 23-196 cmH2O (Powerbreathe Plus, UK). While MIP values were increased by 10% in the study, the first measurement value was determined as 15%, since the placebo effect in IMW-D was accepted as 15% of MIP in the literature. In addition, since 40% or 50% of the MIP value was used in previous studies, 45% of the MIP was also measured to see the effect of small pressure changes in this range.

Spirometric Measurement

Mikrolab 3300 brand spirometer device was used in order to measure the dynamic lung volume and capacity of the participants. In the study, forced vital capacity (FVC-lt), forced expiratory volume in the first second (FEV1-lt) and peak expiratory flow rate (PEF-lt/sec) measurements were taken from dynamic lung volumes and capacities. The measures were conducted as the participants sitting confortably, whose noses are attached with clips while breathing through their mouths (Marangoz et al., 2016).

Statistical analysis

The data were analyzed through SPSS 24 program. The normality distribution of the data was determined by the Shapiro-Wilk test, and the Kruskal Wallis H test was used to determine the differences between the measurements. The significance level of the study was accepted as p<0.05.

Results

Table 1

Comparison of Different MIP Percentages and Differences in Respiratory Parameters

Variable	**Measurement Method**	**$\bar{x}$ ± Sd**	**F**	**p**
FVC (lt)	MIP %15	3.66 ± .62	1.817	.11
	MIP %30	3.84 ± .58		
	MIP %40	3.76 ± .57		
	MIP %45	4.01 ± .60		
	MIP % 50	3.91 ± .65		
	MIP %60	3.98 ± .73		
FEV1 (lt)	MIP %15	3.47 ± .60	2.129	.06
	MIP %30	3.64 ± .58		
	MIP %40	3.55 ± .61		
	MIP %45	3.82 ± .61		
	MIP % 50	3.79 ± .62		
	MIP %60	3.78 ± .67		
PEF(lt/sn)	MIP %15	6.25 ± .41a	4.263	.00***
	MIP %30	6.38 ± .48		
	MIP %40	6.59 ± .43		
	MIP %45	6.65 ± .40 b		
	MIP % 50	6.48 ± .39 b		
	MIP %60	6.43 ± .50		

***p<0,001 a, b: Different letters represent the difference between groups

MIP= maximum inspiratory pressure FVC= forced vital capacity FEV1= forced expiratory volume PEF= peak expiratory flow

When the table is examined, it is evident that while there was a signifcant difference between 15% of MIP and %40, %45, it was determined the highest improvement among these values was 45%, 50% and % 60 of MIP in FVC, FEV1 and PEF values.

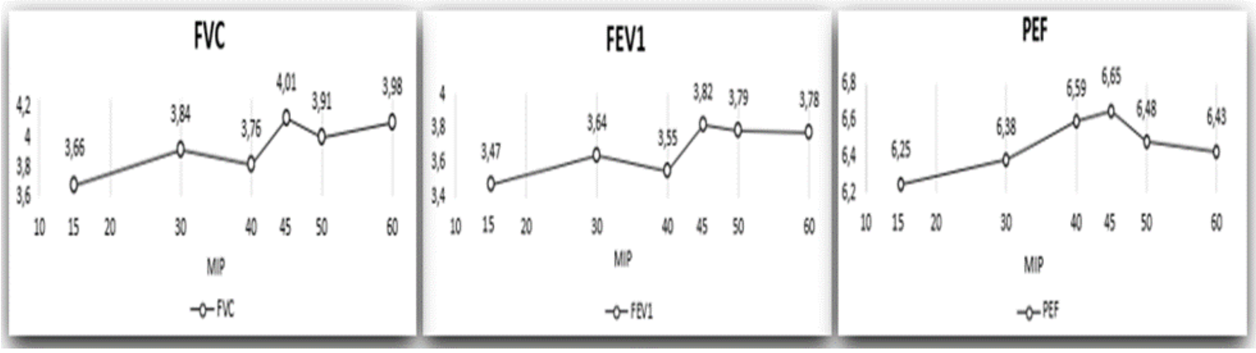

Figure 2. Comparison of Different MIP Percentages and Differences in Respiratory Parameters

Discussion

Respiratory muscle warm-up exercises have effects on the increase in the functional capacity of the respiratory muscles (Volianitis et al., 1999) and the decrease in respiratory muscle fatigue with this increase (Volianitis et al., 2001b). The reason for these effects is explained by the more efficient use of the force produced due to the increase in the muscle's ability to contract and the force of contraction (McConnell et al., 1997).

Respiratory muscles phenomena are regarded by sports scientists as one of the important criteria in revealing performance. The endurance of the respiratory muscles is important in building resistance to fatigue. One of the most commonly used and non-invasive methods for the evaluation of respiratory muscles is MIP measurement (McConnell, 2011; Hautmann et al., 2000; Volianitis et al., 2001a). MIP is a widely used index of inspiratory muscle strength which reflects the combined force-generating capacity of the inspiratory muscles during a short, quasi-static contraction (Larson et al., 1993). When the current literature is examined, it has been seen that the method used to determine the exercise intensity of the respiratory muscles in acute and chronic studies is 15% of MIP (placebo) or 40% of MIP (Özdal, 2016; Çelik et al., 2021; Yilmaz and Özdal, 2019). This intensity level was assumed to approach the upper loading limit before diaphragm fatigue occurs (Volianitis et al., 2001a). However, contrary to this information, Sheel et al. stated in a study that there was no evidence of inspiratory muscle fatigue after three minutes of inspiratory resistive loading against 80% or 95% of the MIP (Sheel et al., 2001). This reveals that the use of intensities higher than 40% of MIP for inspiratory muscle warm-up exercises does not cause inspiratory muscle fatigue (Arend et al., 2016). In a study conducted by Arenda et al. on athletes, the effect of the IMW-D protocol applied with different MIP percentages on MIP values was examined. After determining the MIP values, IMW-D protocol was applied in 15%, 40%, 60% and 80% of MIP on separate days. 15% and 40% of MIP gives 2 sets of 30 inspirations, 1 minute rest between sets, 2 sets of 12 inspirations at 60% of MIP, 2 minutes of rest between sets, and 2 sets of 6 inspirations at 80% of MIP, 3 minutes rest between sets. As a result of the study, it was stated that two sets of 12 inspirations in 60% of MIP in IMW-Ds would be more beneficial and could shorten the warm-up time (Arend et al., 2016).

When the literature is examined, a limited number of studies have been found regarding the application of a different method in inspiratory muscle warm-up exercises, except for MIP 15% (placebo), which is generally used to determine the exercise intensity, or 30 inspirations in MIP 40%, 2 sets and 2 minutes rest between sets. In these studies, the effects of IMW-Ds applied at different MIP intensities were examined over MIP values. In the current study, the evaluation of the effects of IMW-Ds on dynamic lung capacities (FVC, FEV1 and PEF) provided a different perspective to the literature, but limited to the discussion.

Previous studies on the effects of respiratory muscle exercises on pulmonary functions have found that IMW-Ds show significant increases in pulmonary functions and lung volumes (Enright et al., 2004; Enright et al., 2006; Enright and Unnithan, 2011; Tenório et al., 2013). On the other hand, it is a widely-known fact that stronger respiratory muscles can eaisly regulate the blood distribution in the respiratory muscles (Harms et al., 2000; Gigliotti et al., 2006; Mostoufi-Moab et al., 1998; Somers et al., 1992). Similarly, it has been stated that IMW-D plays an active role in regulating this event as it increases respiratory muscle strength (Volianitis et al., 2001a; Volianitis et al., 2001c; Lin et al., 2007; Leicht et al., 2010; Lomax et al., 2011; Lomax and McConnell, 2009; Kantarson et al., 2010; Tong and Fu, 2006). Kantarson et al. in their study on 22 people with a mean MIP of 103.73±25.29 cmH2O, performed a 6-minute running test of IMW-Ds of different intensities of MIP (30%-40%-50%) investigated the changes in running distance. According to the results, it was stated that the running distances of IMW-Ds made at different intensities increased more than those who were not subject to this protocol, and the highest increase was obtained in IMW-Ds made at 40% of the MIP. They also stated in the same study that the degree of dyspnea perception, which they determined with the Borg scale, decreased with the IMW-D (Kantarson et al., 2010). Another study on 26 healthy individuals by Özdal, the acute effects of IMW-Ds on respiratory functions was examined. The individuals participating in the study were divided into three groups; the control group (not doing any respiratory exercise), the IMW-D placebo group (doing 2 sets with 15% of MIP, 30 repetitions each) and the IMW-D group (2 sets with 45% of MIP, 30 repetitions). As a result of the study, while there was no statistically significant difference in respiratory parameters between the control group and IMW-D placebo group, it was determined that the IMW-D group significantly improved in SVC, IVC, FVC, FEV1, MVV and MIP values compared to the control group. It was stated that the responsible mechanisms were probably related to the increase in inspiratory muscle strength and the cooperation of the upper thorax, neck and respiratory muscles, and the increased level of reactive O2 species in the muscle tissue, and potentially the improvement of muscle O2 distribution until use (Özdal, 2016).

Conclusions

As a result, it has been determined in the literature that IMW-Ds made with 40% MIP not only improve athletic performance, but also benefit MIP values. However, in this study, it was observed that performing IMW-Ds with 45%, 50% and 60% of MIP resulted in higher improvement in respiratory parameters. For this reason, it can be said that sedentary people as well as athletes who want to improve their respiratory parameters can also train with 45%, 50% and 60% of MIP without depending on 40% of the MIP applied only in the literature for a higher improvement in their IMW-D.

Ethics Committee Permission Information

Ethics review board: Niğde Ömer Halisdemir University Non-Invasive Clinical Research Ethics Committee

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Issue number of the ethics evaluation document: 2021/85

Author Contributions

All authors read and approved the final version of the manuscript. The contributions of all authors have been described in the following manner:

Conception: S.İ., Z.B.A., G.Y. conceived the original idea.

Performance of Work: S.İ., Z.B.A., G.Y., N.E.P., S.K. conceived and planned the experimental settings required for data collection S.İ., Z.B.A., N.E.P., G.Y., S.K. performed the measurements.

Interpretation or Analysis of Data: S.İ., Z.B.A.

Preparatıon of The Manuscript: S.İ., Z.B.A., G.Y., N.E.P., S.K. took the lead in writing the manuscript Z.B.A. processed the experimental data, performed the analysis, drafted the manuscript.

Supervision: S.İ., Z.B.A. supervised the project.

Conflict of Interest Declaration:

The author(s) did not have a conflict statement regarding the research.

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