

Results of physical rehabilitation of primary school children with recurrent bronchitis at sanatorium

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Abstract

The aim of the study was to investigate the peculiarities of the impact of two rehabilitation programs on physical health and quality of life indicators, as well as comparison of their effectiveness in the main and control groups. The main hypothesis was that the inclusion of elements of the respiratory practice of yoga, the Buteyko and Strelnikova techniques, corrective exercises in the procedure of physical therapy (therapeutic exercises, hydrokinesis therapy), as well as ultraviolet irradiation of the tonsils and massage with an emphasis on posture correction, can improve the effectiveness of a bunch of restorative treatment in sanatorium. Materials of the study were received during the research on the basis of the sanatorium "Malyatko" (Uzhgorod). The contingent of the subjects: 109 children of 7-9 years; 48 of them are with moderate changes in Index Tiffeneau and 61 are without significant changes. The study reflects the dynamics in the groups according to the parameters of the external respiration, key aspects in the changes of the percentage of the levels in the groups based on the results of Stunge and Genchi respiratory tests, the dynamics of the main indicators 6MWT and adaptation indices, changes in the angles of biogeometry profile posture and quality of life for PedsQL. The analysis revealed the existence of reliable changes in most key indicators in all groups of children. However, the comparison of the final results found that the main groups had statistically better results than those under the standard protocol. This confirmed the benefits of the program introduced above the standard one. In the distant period, the main groups were also characterized by a statistically lower frequency of exacerbations.

Key words: physical therapy, exercise, pediatrics, recurrent bronchitis, health resort.

Introduction

According to the results of statistical studies of the structure of children diseases, the first place is taken by diseases of the respiratory system, among which respiratory diseases predominate (Zar, & Ferkol, 2014; Gaborets, & Dudina, 2017; Grygus, 2017). Nonspecific inflammation of the respiratory tract with frequent recurrent episodes of their occurrence are common among children and practically do not get prevented, and the episodes of illnesses are poorly treated, which determines the urgency of the problem (Khrystova, 2012; Ishak, & Everard, 2017; Nesterenko, 2017; Gozhenko et al., 2018a; Gozhenko et al., 2018b).

The group of such diseases includes recurrent bronchitis (RB), which can be transformed into bronchial asthma or chronic bronchitis (Ishak, & Everard, 2017; Grygus et al., 2017, 2019; Törmänen et al., 2018) and affect the deterioration of the quality of life and reduce the health of the population (Doll, & Miravittles, 2005).

Recurrent bronchitis has a fairly wide range of etiologic causes, and the pathogenic mechanisms for the formation and prolongation of the inflammatory process do not have a single conceptual view. The leading role in the formation of RB is most often given to persistent viral and bacterial infections, environmental disadvantages, impairment of the functioning of the immune system and social factors (Doll, & Miravittles, 2005; Jesenak, Ciljakova, Rennerova, Babusikova, & Banovcin, 2011; Lemko, Vantyukh, Lukashchuk, Kopolovets, & Popadinets, 2015; Demchenko, 2016; Kurt, Zhang, & Pinkerton, 2016; Raniszewska et al., 2016; Zakirov, Safina, & Shagiahmetova, 2016; Ishak, & Everard, 2017; Nesterenko, 2017).

In recent years, children with RB and those who are often and severely ill are given more and more attention in researches about the structure of morbidity (Jesenak, Ciljakova, Rennerova, Babusikova, & 2796

Banovcin, 2011; Ivasyk, 2018), the state of physical health (Nechipurenko, 2014; Umlawska, & Lipowicz, 2016), the feasibility and effectiveness of using pharmacological therapy (Lezhenko, Pashkova, & Pantyushenko, 2012; Falanga, Del Genio, & Galdiero, 2021), the results of the use of physical rehabilitation facilities (Khrystova, 2012; Demchenko, & Kopytina, 2016; Ivasyk, 2018; Morrow, 2019). However, despite the existing positive experience of using physical means of rehabilitation at different stages of rehabilitation among the often sick children with bronchopulmonary pathology, the problem of both isolated and complex use of physical exercises, preformed and natural physical factors in the conditions of a sanatorium in children of elementary school age with recurrent bronchitis still remains unresolved in many respects.

Purpose of the research – to compare the effectiveness of standard and modified programs of physical rehabilitation of children with recurrent bronchitis at the sanatorium recovery stage.

Material & methods

The work is carried out in accordance with the scientific theme of the Department of Physical Rehabilitation of the State University "Uzhhorod National University" for 2011-2015 "New technologies in physical rehabilitation, assessment of the quality of life of different population groups in diseases of internal organs and systems of the body and musculoskeletal system" (number of state registration 0111U001870) and theme "Restoration of the psychophysical potential of the body of people of all ages and sex who have a deviation in their health, using the latest rehabilitation technologies" for 2016-2020 (number of state registration 0116U003326).

Participants. Working materials were received during the research on the basis of the sanatorium "Malyatko" (Uzhgorod). The study involved 109 children aged 7 to 9 (53 of them were boys (48.6%) and 56 girls (51.4%)) who were referred to sanatorium treatment with a diagnosis of "recurrent bronchitis", for 2011-2013. Inclusion of patients in the study occurred with the consent of the treating physicians, as well as the informed consent of the rehabilitation team and parents. The research was carried out in compliance with the international principles of the Helsinki Declaration of the World Medical Association (World Medical Association, 2013), and in accordance with the Law of Ukraine "Fundamentals of Ukrainian Legislation on Healthcare" (Law of Ukraine, 1992) on ethical norms and rules for conducting medical research involving human.

Procedure / Test protocol / Skill test trial / Measure / Instruments. At the state of the respiratory system, children were divided into group 1 (G1 - with moderate changes in Index Tiffeneau (IT)) and group 2 (G2 - without significant changes in IT values). So, 48 (44%) children were enrolled in G1, and 61 (56%) – in G2. In the formal experiment, the children of the groups G1 and G2 examined by random sampling were divided into the main (MG) and control (CG) subgroups each: G1 at MG1 (n = 23) and CG1 (n = 25); G2 on MG2 (n = 32) and CG2 (n = 29). Children in the subgroups MG1 and MG2 were engaged in the programs of physical rehabilitation (21 days), and children from the subgroups CG1 and CG2 - according to the standard program of the medical institution, which included medical gymnastics, hydrokinesis therapy, physiotherapy, massage, medical dosed walking, games, phytotherapy. In the developed program therapeutic exercises included elements of respiratory practices of yoga, elements of Buteyko and Strelnikova techniques, special respiratory exercises (depending on the presence of obstructive changes), and corrective exercises.

The procedure for hydrokinesis therapy in the main groups had the following features: the preparatory part for hydrokinesis therapy on the land was extended, the complex of general and respiratory exercises – was modified, corrective exercises for posture were introduced. Among the physio procedures, in addition to inhalations with mineral water, chlorophyll, oxygen, halo-aerosol therapy, the main groups received the procedure of ultraviolet irradiation of the tonsils. Massage procedure in the main groups additionally included methods for elimination posture disorders. A content analysis of diseases' history was conducted. An assessment of the state of the function of external respiration was performed using Spirolab III spiograph, Shtange and Genchi functional respiratory tests. A 6-minute walk (6MWT) test was conducted in a corridor of a sanatorium with a length of 50 m with markings every 5 m of distance, in order to determine tolerance to physical activity. After the first attempt, in 30 minutes, the test was repeated. For a more detailed description of the adaptation reserve, the time of recovery of heart rate (HR) was determined after the first and repeated testing. The quantitative estimation of the adaptation reserve was determined as a part of dividing the results of the second test by the result of the first test. The Adaptation Index (IA_D) and the Ratio Recovery Adaptation Index (IA_T) were estimated (Tolmachova, Bohmat, Nikonova, & Holovko, 2014).

The Adaptation Index was calculated by the formula:

$$IA_D = D_2 / D_1, \text{ a.u.,}$$

where D₂ — second test distance, m;

where D₁ — first test distance, m.

If the IA_D value exceeded 1, it was interpreted as having an adaptation reserve, and vice versa, with a value less than 1 as the depletion of the adaptation reserve.

The Ratio Recovery Adaptation Index (IAT) was calculated by the formula:

$$IAt = t_2/t_1, \text{ a.u.},$$

where t_1 - recovery time to baseline heart rate after the first test;

where t_2 - recovery time to baseline heart rate after the second test.

Data collection and analysis / Statistical analysis. For quantitative specification and registration of quantitative characteristics of the biogeometry profile of patients' posture, a computer photometry method was used. The quality of life assessment was carried out using the International Standardized Quality of Life Questionnaire (PedsQLTM 4.0 Generic Core Scales, France) upon admission and 2-3 months after discharge. All statistical analyses were conducted using Statistic 6.0 (StatSoft, USA). Mean \pm standard deviation (M \pm SD), median (Me), upper and lower quartiles (25%; 75%) were measured. Differences between the experimental points were evaluated by Student's *t*-test and considered as significant for $p < 0.05$.

Results

Anamnesis analysis revealed the following features. The duration of the disease after diagnosis of RB for the first time was 2 years in 7 (6.4%) children, 3 years - in 48 (44%), 4 years - in 41 (37.6%), and 5 years - in 13 (11.9%). The average duration of the disease was 3.55 ± 0.79 years with Me (25%; 75%) - 3 (3; 4). The frequency of exacerbations of RB for the last year was the following: 21 children (19.3%) have 3 times a year, 76 children (69.7%) - four times and 12 (11%) - five times. The average frequency of exacerbations was 3.92 ± 0.55 times a year. Fatigue was noted by 61.5% of children. The main indicators in the children's groups had the following features (Fig.1).

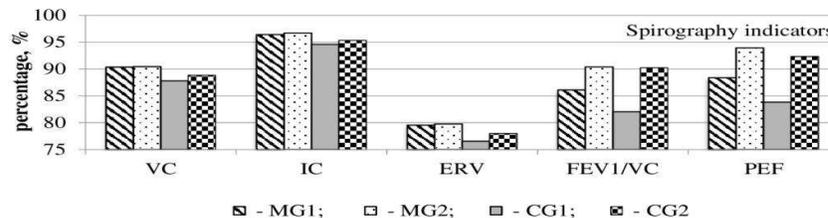


Fig. 1. Spirography results of children 7-9 years of patients with recurrent bronchitis: VC – Vital Capacity; IC – Inspiratory Capacity; ERV – Expiratory Reserve Volume; FEV1 – Forced Expiratory Volume in one second; FEV1/VC – Index Tiffeneau; PEF – Peak Expiratory Flow). MG – main group; CG – control group

Rehabilitation programs have positively influenced the function of external respiration, which is confirmed by a significant increase in vital capacity (VC) and, accordingly, its components in all groups of children ($p < 0.001$). However, in the main groups, a number of indicators has grown more substantially. Thus, the VC index in children of MG1 significantly differed from CG1 ($p < 0.01$), and in MG2 from CG2 ($p < 0.01$). In MG1, the value of the VC after the completion of the rehabilitation course increased by 12.57% to $90.35 \pm 1.67\%$; in CG1 the gain was somewhat lower and amounted 9.72% to $87.80 \pm 1.91\%$. In groups that did not have significant IT changes at the time of accession, there was a similar trend. Thus, in MG2 the increase of VC was noted at 7.69% to $90.47 \pm 1.80\%$, and in CG2 it was 5.41% to $88.86 \pm 2.76\%$. The inspiratory capacity (IC) was significantly different when comparing the main and control groups. In MG1, the IC index increased by 11.60% to $96.43 \pm 2.29\%$; in CG1 the gain was somewhat lower and amounted 10% to $94.60 \pm 3.64\%$ ($p < 0.01$). The forced vital capacity (FVC) index in MG1 increased by 13.22% to $88.83 \pm 2.41\%$; in CG1 - by 6.24% to $82.04 \pm 2.59\%$; in MG2 - by 8.19% to $89.78 \pm 1.86\%$; In CG2 - 5.93% to $88.24 \pm 2.65\%$. That indicates a greater activation of reserves in main groups. At the same time, the values of children from the MG1 group were compared with the values of MG2 at the time of discharge ($p > 0.05$).

Index Tiffeneau did not undergo significant changes in the groups MG2 and CG2 ($p > 0.05$). Among the children of MG1 and KG1 the improvement of IT by 13.04% and 8.24% respectively was marked, which influenced the establishment of a significant difference between the groups ($p < 0.01$). Peak expiratory flow (PEF) changes at the time of discharge from the sanatorium were detected in all groups in comparison with the initial values. However, the increase in values in children of main groups was more significant, which is confirmed by the presence of statistical differences between the results of MG1 and CG1 groups ($p < 0.01$), MG2 and KG2 groups ($p < 0.05$), as well as quantitative changes, namely: MG1 the indicator increased by 18.82% to $88.39 \pm 2.69\%$; in CG1 - by 13.12% to $83.84 \pm 2.32\%$; in MG2 - by 5.47% to $93.94 \pm 2.30\%$; In CG2 - by 3.04% to $92.35 \pm 1.32\%$.

The forced inhaled vital capacity index (FIVC) in MG1 increased by 16.08% to $83.04 \pm 2.14\%$; in CG1 - by 7.44% to $74.84 \pm 3.76\%$; in MG2 - by 11.22% to $79.03 \pm 1.67\%$; in CG2 - by 6.27% to $74.93 \pm 1.79\%$, which indicates a greater activation of reserves for the execution of a forced inspiration in the main groups.

Thus, in the main groups of children after the rehabilitation, 63.6% of the results of the Shtange test were within the norm, which is 25.4% more than on admission, while the remaining 36.6% in these groups had lowered results. The children of the control groups at the time of discharge had some values that corresponded to the norm (44.4%), and those that were reduced (55.6%), while the increase in the proportion of normal values of the test was only 3.7%. There was a significant difference in the distribution of the values of the Shtange test between the children of the main and control groups at the time of the re-examination ($p < 0.05$).

Among the children of the main groups, after rehabilitation, 96.4% of the Genchi test results were within the norm, which is 25.6% higher than on admission, while the remaining 3.6% in these groups had lower results. The children of the control groups at the time of discharge had 81.5% of the values within the norm and 18.5% lower than the norm, while the growth of the share of normal values of the Genchi test was 20.4%. A significant difference was found between the children of the main and control groups at the time of the re-examination ($p < 0.05$). The analysis of the dynamics of indicators determined during the 6MWT showed the benefits of the proposed program. Among children of MG1, the value of D2 after the completion of the course of rehabilitation increased by 58.26 m (14.5%) to 459.35 ± 14.48 m; in CG1 the gain was somewhat smaller and amounted to 33 m (8.4%) to $428.20 \pm 16.00\%$. Among the groups of children who did not have significant IT changes at the time of admission, similar dynamics was observed. Thus, in the MG2 group, an increase in D2 was noted at 64.53 m (15.8%) to 473.44 ± 9.87 m, while in the CG2 group by 33.8 m (8.2%) to 444.66 ± 17.62 m. The dynamic of the D2 indicator shows the lower effectiveness of the standard program for improving the state of the cardio respiratory system and overall endurance. The dynamic of the IA_D changes was as follows: significant differences in comparison with the initial results were found only among the children of the main groups. Thus, in MG1, the growth of IA_D was recorded with 1.03 ± 0.03 a.u. to 1.05 ± 0.04 a.u. ($p < 0.001$), and in MG2 with 1.05 ± 0.05 a.u. to 1.08 ± 0.03 a.u. ($p < 0.001$), which confirms the better effectiveness of the developed rehabilitation program for children with RB. Analysis of the angles of the biogeometry profile of posture revealed differences between the main and control groups in the frontal and sagittal planes, which reflected the effectiveness of the rehabilitation programs. The value of the angle β_2 (formed by the line of the horizon and the segment connecting the acromions) was significantly better in the children of the main groups. We also note that Me (25%; 75%) in MG1 was 1.83 ($1.26; 2.61$)°, in CG1 2.90 ($2.62; 5.50$)°, in MG2 2.55 ($2.00; 2.93$)°, in CG2 2.89 ($2.66; 3.35$)°. The greatest improvement of the angle β_2 was recorded in the MG1 group. Thus, the value has significantly decreased by 1.66° ($p < 0.01$). Among children of MG2, the average result decreased by 1.38° ($p < 0.01$), in control groups the changes were lower, and in CG1 they were not reliable ($p > 0.05$).

In the results that were obtained at the time of the discharge, the main groups had better performance and the angle β_3 (formed by the line of the horizon and the segment connecting the points of the lower corners of the shoulder blades). The average result in MG1 was significantly lower than in CG1 and was $2.82 \pm 1.63^\circ$ ($p < 0.01$), and its decrease by 2.37° was reliable ($p < 0.01$). Me (25%; 75%) in MG1 and CG1 respectively was 2.62 ($1.41; 4.07$)° and 5.42 ($3.37; 6.73$)°. Similar dynamics was observed among children without initial reduction of IT. The average value for children of MG2 was significantly lower than in CG2 and was $3.25 \pm 0.95^\circ$ ($p < 0.01$), and its decrease during the rehabilitation course at 1.55° was reliable ($p < 0.01$). The statistical significance of Me (25%; 75%) at the time of discharge in MG2 was 3.23 ($2.74; 3.80$)°, and among CG2 it was 4.16 ($3.58; 5.28$)°. The reliable positive dynamics of the cumulative quality of life scale has been observed in children of the main groups, which was mainly due to physical functioning and role functioning.

The second questionnaire, conducted after 2-3 months from the date of discharge from the sanatorium, revealed a significant difference between the MG1 and CG1 by the indicator of the total scale ($p < 0.01$). Thus, the average result in MG1 was higher and amounted to 82.14 ± 2.83 points, and among children of CG1 80.04 ± 2.24 points. At the same time, compared with the initial values of the scale in the MG1, growth was recorded at 3.03 points ($p < 0.01$), and in CG1 there was no statistically significant increase ($p > 0.05$). Among the groups of children without significant IT changes, there were also significant differences in the total score after the sanatorium treatment with the use of physical rehabilitation facilities ($p < 0.01$): in MG2 the figure was 82.24 ± 2.67 points and was greater than in CG2, where the result was 80.55 ± 2.06 points. On the other hand, in comparison with the results of the first questionnaire on the overall scale in MG2, improvement by 1.57 points was statistically significant ($p < 0.01$), and changes in CG2 were not reliable ($p > 0.05$) (Fig.2).

Comparing the frequency of exacerbations during the year after discharge, it should be noted that there are significant ($p < 0.001$) improvements in all groups: MG1 from 4.1 ± 0.63 to 2.4 ± 0.67 times a year; CG1 from 3.9 ± 0.49 to 2.9 ± 0.68 times per year; MG2 from 3.9 ± 0.49 to 2.2 ± 0.47 times a year; CG2 from 3.8 ± 0.49 to 2.5 ± 0.51 times a year. However, more significant changes in the main groups are confirmed by statistical differences between the MG1 and CG1 groups ($p < 0.01$), MG2 and CG2 groups ($p < 0.01$), which was not observed according to the initial survey.

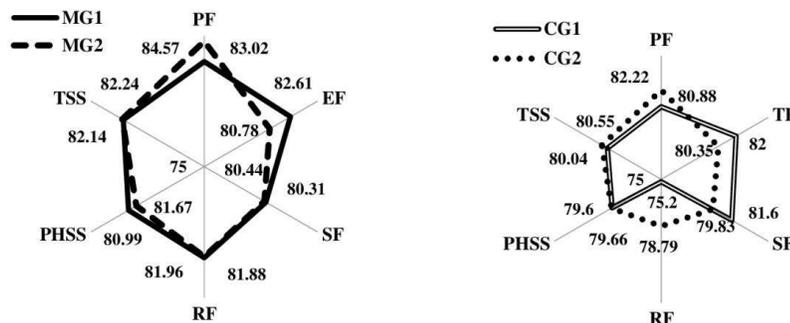


Fig. 2. Quality of life of children with recurrent bronchitis according to child self-report forms of questionnaires after the rehabilitation course: PF - physical functioning; EF - emotional functioning; SF - social functioning; RF - role functioning; PHSS - psychosocial health summary score; TSS - total scale score. MG – main group; CG – control group

Discussion

The functional state of the respiratory system in the period between relapses among children with recurrent bronchitis according to the literature may be either normal (Umławska & Lipowicz, 2016) or lower (Rodrigues et al., 2019). Among children with RB it was also noted the changes in the cardiovascular system (Tsupak et al., 2017), the presence of disturbances of posture (Golubova, & Lyubchik, 2006; Ivasyk, 2016), which, along with the etiopathogenetic features, requires clarification of the algorithms of treatment and the use of physical rehabilitation at different stages of recovery. It should be noted that the means of therapy, rehabilitation and preventive measures used in children with recurrent bronchitis and those who are often sick should have no adverse effects on the overall development of the organism and the functioning of its systems, or such undesirable effect should be minimal (Torokhtin, Moroz, & Birkovich, 2013; Ivasyk, & Tyravska, 2016).

Data obtained during patient surveys allowed to analyze the physical development at the time of arrival to the sanatorium, the initial functional state of the respiratory system and the cardiovascular system, to determine the general features of the static stereotype, which determined the possibility of conducting rational changes in the process of restorative spa treatment and to optimize the positive dynamics of indicators, as well as to check the effectiveness of the implementation of the program of physical rehabilitation through the methods of mathematical statistics, comparing the results obtained at stages of the study in groups of children with recurrent bronchitis. The presence of abnormalities in the function of the apparatus of external respiration in children has been confirmed. Previously it was reported that there was no functional remission in the inter-incident period: the volumetric values of the VC and FVC tests, bronchial tubes of different diameters remained low (Tsupak et al., 2017). However, given the division of our children into groups with and without IT changes, we can say that among children with RB there are no significant changes in the function of external respiration, and their main parameters of the functioning of the respiratory system are within the limits of the conditional norm and norm. This conclusion, on the other hand, confirms the statement of specialists that in children with RB, the lung function in the period between relapses is not impaired (Umławska, & Lipowicz, 2016). The use of A 6-minute walk (6MWT) test allowed to supplement the data on tolerance to physical activity in children with recurrent bronchitis and to investigate the dynamics that occurred in the groups of children under the influence of developed and standard rehabilitation programs in the sanatorium. The revealed quantitative characteristics of the biogeometry profile of posture confirm the opinion of scientists that breach of posture in children with chronic bronchopulmonary pathology can be considered as a co-morbidity (Nikitina, Shkrebko, & Bychkova, 2013; Ivasyk, 2018). Confirmed that posture impairment can lead to functional violations of both respiratory volume and air flow velocity in the respiratory tract, and correlation between the angle of the sagittal plane α_2 and the values of ERV ($\rho = -0.33$, $p < 0.01$), FEV1 ($\rho = -0.37$, $p < 0.01$), IT ($\rho = -0.45$, $p < 0.01$), MEF25-75 ($\rho = -0.38$, $p < 0.01$) confirms that impaired posture deepens the decrease in the function of the respiratory system (Golubova, & Lyubchik, 2006; Ivasyk, 2016).

We have confirmed the results of research on the effectiveness of the effects of physical rehabilitation on the functional reserves of the respiratory system (Areshina, & Lyannoy, 2012; Torokhtin, et al., 2013; Nechipurenko, 2014; Ivasyk, 2018).

Conclusions

The evaluation of the indicators of external respiration before physical rehabilitation revealed lower values of the main indicators, especially among children belonging to the group with moderately lower values of Index Tiffeneau. When entering the sanatorium, the duration of the disease was set at the level of 3.55 ± 0.79 years, and the frequency of exacerbations was 3.92 ± 0.55 times a year.

The statistical analysis of spirographic data confirmed that the quantitative changes in the main volume and speed indices among the children of the main groups were better. In addition, the children of the main group with initially established moderate IT reductions increased the VC by 12.57% ($p < 0.01$) and statistically reached the values ($p > 0.05$) that were obtained after rehabilitation in the children of the main group without initially revealed reductions in IT, which also increased by 7.65% ($p < 0.01$).

The 6MWT results also had a general tendency for improvement in children's groups. Indicators of length of distance in the first and second attempts significantly increased ($p < 0.01$) in all groups, but the reliable differences between the main and control groups ($p < 0.01$) confirmed the benefits of the developed program. Along with this, the index of adaptation has significantly improved only in the main groups ($p < 0.01$). The index of adaptation of rhythm recovery has significantly improved in all groups of children ($p < 0.01$), but the statistical differences between the main and control groups ($p < 0.01$) indicated the prerogative of the developed program of physical rehabilitation. According to the analysis of the parameters of the biogeometry profile of the posture, a significant improvement of the vast majority of the angles of the frontal and sagittal planes was found among the children of the main groups, while among the control group, improvement was noted only at the values of some angles. The developed program of physical rehabilitation also influenced the dynamics of indicators of life quality, which turned out to be a significant increase in the points of the spheres of physical and role functioning and, accordingly, the total scale.

Conflict of Interest The authors declare that they have no conflict of interest.

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