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The Effect of Postoperative Mobilization with a Pedometer on Pulmonary Functions and Length of Postoperative Hospital Stay in Patients Undergoing Lung Resection: Cross-Sectional Study

Akciğer Rezeksiyonu Uygulanan Hastalarda Pedometre ile Postoperatif Mobilizasyonun Pulmoner Fonksiyonlar ve Postoperatif Yatış Süresi Üzerine Etkisi: Kesitsel Çalışma

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ABSTRACT Objective: Mobilization takes an important place in providing postoperative pulmonary rehabilitation and is accepted as an effective factor in accelerating the recovery process and improving physical and mental health. This study aims to determine the effect of postoperative mobilization with a pedometer on pulmonary functions and length of postoperative hospital stay in patients undergoing lung resection. **Material and Methods:** This descriptive and cross-sectional study was conducted with the participation of 52 patients in a thoracic surgery clinic of a university hospital . The "patient identification form" and the "patient results evaluation form" were used to collect the data. Data were analyzed using IBM SPSS Statistics 22.0. Shapiro-Wilk test was used to test the compatibility of the data to normal distribution. The Spearman correlation analysis was used in analyzing the data. **Result:** It was revealed that the total step count and walking distance did not affect the postoperative forced expiratory volume in 1 second (FEV_1), forced vital capacity (FVC), and FEV_1/FVC values ($p>0.05$). A weak negative correlation was determined between total step count and the length of postoperative hospital stay ($p<0.05$). It was found that 84.6% of the patients were satisfied/very satisfied with the use of a pedometer. **Conclusion:** The study demonstrated that the increase in the step count was not effective on pulmonary functions in the early period but shortened the length of postoperative hospital stay. We recommend the use of a pedometer after lung resections since it standardizes the mobilization measurement, promotes mobilization, and shortens the length of hospital stay owing to its contributions to pulmonary physiotherapy.

Keywords: Length of stay; lung capacities; nursing; postoperative period

ÖZET Amaç: Mobilizasyon; postoperatif pulmoner rehabilitasyonun sağlanmasında önemli bir yer tutmakta, derlenme sürecinin hızlandırılmasında ve fiziksel ve mental sağlığın geliştirilmesinde etkin bir faktör olarak kabul edilmektedir. Bu çalışmanın amacı, akciğer rezeksiyonu uygulanan hastalarda pedometre ile postoperatif mobilizasyonun pulmoner fonksiyon, postoperatif yatış süresi üzerine etkisini belirlemek ve ikincil olarak pedometre kullanımının hasta memnuniyetine etkisini değerlendirmektir. **Gereç ve Yöntemler:** Tanımlayıcı ve kesitsel tipteki bu araştırma bir üniversite hastanesinin göğüs cerrahi kliniğinde yatarak tedavi edilen 52 hastanın katılımıyla gerçekleştirildi. Verileri toplamak için "hasta tanıtım formu" ve "hasta sonuçları değerlendirme formu" kullanıldı. Veriler, IBM SPSS Statistics 22.0 kullanılarak analiz edildi. Verilerin normal dağılıma uygunluğunu test etmek için Shapiro-Wilk testi kullanıldı. Verilerin analizinde Spearman korelasyon analizi kullanıldı. **Bulgular:** Toplam adım sayısı ve yürüme mesafesinin postoperatif birinci saniyedeki zorlu ekspiratuar volüm [forced expiratory volume in 1 second (FEV_1)], zorlu vital kapasite [forced vital capacity (FVC)] ve FEV_1/FVC değerlerini etkilemediği belirlendi ($p>0,05$). Toplam adım sayısı ile ameliyat sonrası hastanede kalış süresi arasında zayıf bir negatif korelasyon belirlendi ($p<0,05$). Hastaların %84,6'sının pedometre kullanımından memnun/çok memnun kaldığı bulundu. **Sonuç:** Araştırma, adım sayısındaki artışın erken dönemde solunum fonksiyonları üzerine etkili olmadığını, ancak ameliyat sonrası hastanede kalış süresini kısalttığını göstermiştir. Pulmoner fizyoterapiye katkıları nedeniyle mobilizasyon ölçümünü standardize etmesi, mobilizasyonu teşvik etmesi ve hastanede kalış süresini kısaltması nedeniyle akciğer rezeksiyonlarından sonra pedometre kullanılmasını öneriyoruz.

Anahtar Kelimeler: Yatış süresi; akciğer kapasiteleri; hemşirelik; postoperatif dönem

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In lung resections, there is a change in pulmonary functions depending on anesthesia, surgery duration and type.[1] Anesthesia causes respiratory system depression, and surgical intervention causes diaphragm dysfunction, leading to a decrease in functional residual capacity.[2] Pulmonary rehabilitation practices are used to activate respiration after lung surgery, to ensure the patency of the bronchi with mucus mobilization, to allow gas exchange, to preserve lung capacity, to reduce pain, and to prevent pulmonary complications.[3] Pulmonary rehabilitation practices are techniques that increase ventilation, bronchial hygiene techniques, pain management, and mobilization.[3,4]

Mobilization takes an important place in providing postoperative pulmonary rehabilitation and is accepted as an effective factor in accelerating the recovery process and improving physical and mental health.[4] Surgical nurses assume an important responsibility in promoting early mobilization, an essential component for improving patient outcomes and survival rates in the management of postoperative care.[5] Walking, one of the mobilization techniques, is a physical activity and can be measured.[6] Pedometers are economical devices that measure the step count to monitor physical activity, especially during walking.[7] Nowadays, it is stated that pedometers are frequently used in health research to measure postoperative mobilization and are effective in increasing the physical activity of patients.[8] Pedometers are shown as motivating tools to increase physical activity. Pedometers increase awareness and motivation to promote activity.[9]

Studies have demonstrated an association between physical activity and length of hospital stay and surgical outcomes.[6,10,11] However, studies revealing the effect of postoperative physical activity on early lung capacity are limited.[12]

This study aims to determine the effect of postoperative mobilization with a pedometer on pulmonary functions and length of postoperative hospital stay in patients undergoing lung resection and secondarily to evaluate the effect of pedometer use on patient satisfaction.

MATERIAL AND METHODS

STUDY DESIGN

This descriptive study was conducted with the participation of 52 patients who underwent lung resection with the uniportal video-assisted thoracic surgery technique, which was performed with a standard muscle-sparing postero-lateral thoracotomy incision or a 5 cm utility incision under elective conditions in a thoracic surgery clinic of a university hospital between April 2019 and March 2020.

SAMPLE

The study population consisted of patients who underwent lung resection. The minimum number of people that should be included in the sample was found as 46 by predicting a power of 95% and an effect size of 0.5 at a 95% confidence level in the G*power program (3.1.9.4) (Germany, University of Kiel). A total of 52 patients were reached within the scope of the study.

INCLUSION AND EXCLUSION CRITERIA

Adult patients who had undergone lung resection, were followed up in the thoracic surgery clinic postoperatively, had normal lung capacity with forced expiratory volume in 1 second (FEV_1)/forced vital capacity (FVC)> 70% as a result of the preoperative pulmonary function test, were mobilized on the postoperative 1st day, did not have any obstacle to mobilization in the perioperative period and did not use any assistive device (walker etc.), did not have any neurological and psychiatric disorders, and who could communicate in Turkish were included in the study.

Patients who did not accept the use of a pedometer, were hospitalized in the intensive care unit for more than 24 hours postoperatively, underwent a procedure on the diaphragm-phrenic nerve, chest wall during the surgery, and who could not be mobilized on the 1st postoperative day (due to pain, dizziness, oxygen requirement etc.) were excluded from the study.

PEDOMETER

Pedometers detect the vertical acceleration movement of the hips during walking.[13] Their advantages

are being portable, inexpensive, and providing objective measurement. Pedometers are devices that measure physical activity in real time, continuously and objectively.[14]

A TNV PM 2000 pedometer (Zhongshan Tender Electric Appliance Co, Ltd, China), which was distributed to the public within the scope of the "fighting obesity movement" campaign, launched by the Turkish Republic Ministry of Health on June 27, 2012, and aiming to inform the society about healthy nutrition and physical activity, was used in the study (Figure 1). A total of 5 devices were obtained from family medicine. The device can record information on the step count (step), walking distance (m), and energy expenditure (kcal) for 7 days, in a way sensitive to acceleration. The information collected is stored in the internal memory of the device. The devices are calibrated and battery-powered, and the batteries were inserted at the beginning of the study. The device can be locked to prevent accidental damage to data. The step count includes data that cover 96 hours starting from the 1st postoperative day.

PULMONARY FUNCTIONS

It was evaluated by a specialist technician using a calibrated spirometer (Chest-Chestgraph HI-105, Tokyo, Japan). FEV_1, FVC and FEV_1/FVC values among pulmonary function test results were evaluated by a thoracic surgeon.[15] The test was conducted with the patient in a sitting position. The test result with the highest value in the 3 measurements was taken as a basis and recorded.[16] All spirometric values were expressed as a predictive value based on age, height, weight, and sex.

FIGURE 1: Pedometer.

DATA COLLECTION FORMS

The "patient identification form" and the "patient results evaluation form" were used to collect the data.

PATIENT IDENTIFICATION FORM

In the form prepared by the researchers with the support of the literature, there are 11 questions questioning sociodemographic characteristics (age, sex, educational status, smoking, alcohol consumption, comorbidity, the presence of chronic obstructive pulmonary disease (COPD), height, weight, body mass index, step length).[10,17]

PATIENT RESULTS EVALUATION FORM

The form was prepared by the researchers. There are a total of 6 questions questioning the surgery-related characteristics of the patients (surgical procedure performed, number of drains, surgery duration, postoperative analgesic type, and length of postoperative hospital stay) and satisfaction with the use of a pedometer. Furthermore, there are 2 charts in the form to record information about the daily step count and pulmonary function test results (FEV_1, FVC and FEV_1/FVC values) of the patients.

DATA COLLECTION

Written informed consent was obtained from the individuals who met the inclusion criteria after the researcher informed the individuals who were planned to undergo lung resection in the thoracic surgery clinic about the study. The patient information form was filled out by the nurse (research nurse) in charge of the service 1 day before the surgery, and the patients were informed about the importance of postoperative mobilization and respiratory exercises. Moreover, it was emphasized that patients should be mobilized every 2 hours after the first mobilization. The preoperative pulmonary function test was performed by a thoracic surgical expert with spirometry (Chest-Chestgraph HI-105, Tokyo, Japan).

All patients were taken to bed rest on postoperative day 0, and respiratory physiotherapy was started using intensive spirometry and assisted coughing at 8 hours postoperatively. In the management of epidural analgesia, bupivacaine hydrochloride 5 mg/mL+fentanyl 0.05 mg/mL (1 cc/kg) was administered through

the epidural catheter for the first 24 hours by the anesthesiologist. A total daily dose of 3 mg/kg tramadol hydrochloride was used in patients receiving intravenous (IV) analgesia. Tramadol hydrochloride 100 mg and paracetamol 500 mg were used in patients receiving IV+oral analgesia.

After the device was turned on, the patient's data (age, height, weight, step lenght) were entered, and the pedometer was activated. The pedometer was placed on the patients' waists at 07.00 on the first postoperative day, and their first postoperative mobilization was performed.[18] Mobilization was monitored by the pedometer for 96 hours on the 1st, 2nd, 3rd, and 4th postoperative days. The patients were told to wear their pedometers when they were awake. The pedometer was removed at 7.00 am on the 5th postoperative day. The pedometer was received by the nurse in charge of the service to record the data. On the 5th postoperative day, the pulmonary function test was applied by a thoracic surgeon to the patients.

In patients whose vital signs are stable and pain is controlled (visual analogue scale score 3 and below), whose oral intake and mobility can be fully provided, without any pathology in terms of clinical, radiological and laboratory findings, whose drains, the decision to discharge is made.

STATISTICAL METHODS

Data were expressed using descriptive statistics (mean, standard deviation, percentage, and frequency). Data were analyzed using IBM SPSS Statistics 22.0 (Armonk, NY, USA). Shapiro-Wilk test was used to test the compatibility of the data to normal distribution. The Spearman correlation analysis was used in analyzing the data. The statistical significance value was accepted as $p<0.05$.

ETHICAL CONSIDERATIONS

The Declaration of Helsinki, Good Clinical Practice Guidelines, and the local ethics committee requirements were taken into account during the study process. The ethical approval required for conducting the research was obtained from the medical faculty scientific research ethics committee (Trakya University Faculty of Medicine, date: December 24, 2018, no: 2018/457; decision number: 21/23), and permission to perform the study was granted by the institution (data: March 13, 2019; serial number: E314001/312671) where the study was conducted. Patients were informed that their information would be used for scientific purposes only and would not be shared outside of the study. Written informed consent form were obtained from the patients before the study.

RESULTS

It was determined that the mean age of the patients was 59.5±12.7 (20-78) years, 80.8% were male, and 80.8% were primary school graduates. It was found that 76.9% of the patients underwent lobectomy (Table 1).

TABLE 1: Patients' sociodemographic and surgery-related characteristics variables (n=52).

Variables		n (%)
Age (year) (Mean±SD)		59.5±12.7
Sex	Female	10 (19.2)
	Male	42 (80.8)
Educational status	Primary education	42 (80.8)
	High school	6 (11.5)
	University	4 (7.7)
Smoking	Yes	35 (67.3)
	No	17 (32.7)
Alcohol consumption	Yes	11 (21.2)
	No	41 (78.8)
Comorbidity	Yes	24 (46.2)
	No	28 (53.8)
The presence of COPD	Yes	2 (3.8)
	No	50 (96.2)
Surgical procedure performed	Wedge resection	4 (7.7)
	Segmentectomy	3 (5.8)
	Lobectomy	40 (76.9)
	Pneumonectomy	5 (9.6)
Number of drains	1	12 (23.1)
	2	40 (76.9)
Surgery duration	2 hours <	8 (15.4)
	2 hours ≥	44 (84.6)
Postoperative analgesic type	IV	4 (7.7)
	Epidural	29 (55.8)
	IV+oral	19 (36.5)
Length of postoperative hospital stayday (Mean±SD)		7.2±1.6
Body mass index$_{kg/m^2}$ (Mean±SD)		25.6±3.6

COPD: Chronic obstructive pulmonary disease; IV: Intravenous; SD: Standard deviation; n: Number of patients.

TABLE 2: Patients' postoperative step count and walking distance (n=52).

Variables (Mean±SD)	Postoperative 1st day	Postoperative 2nd day	Postoperative 3rd day	Postoperative 4th day
Step count (step)	887.0±1112.2	1430.8±1345.0	1816.6±1595.2	2242.6±1692.4
Walking distance (m)	444.6±501.9	739.8±644.4	945.4±793.2	1130.2±855.5

SD: Standard deviation; m: meter.

TABLE 3: The relationship between patients' total step count/walking distance and postoperative pulmonary function values/length of postoperative hospital stay (n=52).

Variables (mean±SD)		Pulmonary function values			Length of postoperative
		FEV_1	FVC	FEV_1/FVC	hospital $stay_{day}$
Total step count (step)	1594.3±1204.4	p=0.981	p=0.987	p=0.525	p=0.026
		r=-0.003	r=-0.003	r=0.090	r=-0.308
Total walking distance (m)	3260±2270	p=0.884	p=0.844	p=0.371	p=0.013
		r=-0.021	r=-0.028	r=0.127	r=-0.344

FEV_1: Forced expiratory volume first second; FVC: Forced vital capacity; FEV_1/FVC: Forced expiratory volume first second/forced vital capacity; r: Spearman correlation analysis; SD: Standard deviation; n: Number of patients.

While the mean step count was measured as 887.0±1112.2 and 2242.6±1692.4 on the first and 4th postoperative days, respectively, the mean step count for 4 days was determined as 1594.3±1204.4 (Table 2). In the study, it was revealed that the total step count did not affect the postoperative FEV_1, FVC, and FEV_1/FVC values (respectively p=0.981, r=-0.003; p=0.987, r=-0.002; p=0.525, r=0.090). While the mean walking distance of the patients for 4 days was determined as 3260±2270 m, no correlation was found between walking distance and postoperative FEV_1, FVC, and FEV_1/FVC values (respectively p=0.884, r=-0.021; p=0.844, r=-0.028; p=0.371, r=0.127) (Table 3). A weak negative correlation was determined between total step count and the length of postoperative hospital stay (p=0.026, r=-0.308). A weak negative correlation was determined between walking distance and the length of postoperative hospital stay (p=0.013, r=-0.344) (Table 3).

It was found that 84.6% of the patients were satisfied/very satisfied with the use of a pedometer. It was revealed that the total step count of the patients who were satisfied/very satisfied with the use of a pedometer was higher than those who were not satisfied (p=0.020, U=84.000) (Table 4).

TABLE 4: Patients' status of satisfaction about pedometer use (n=52).

Status of satisfaction		n (%)
Status of satisfaction about pedometer use	Satisfied/very satisfied	44 (84.6)
	Not satisfied	8 (15.4)
	Not satisfied at all	0 (0.0)

n: Number of patients.

DISCUSSION

In their study, El-Rauf et al. determined that pulmonary functions were better preserved in patients undergoing the upper abdominal surgical intervention who were mobilized early (before 48 hours) compared to patients who were mobilized on the 3rd postoperative day.[19] In the systematic review of Himbert et al., it is stated that postoperative exercise programs improve pulmonary functions in patients undergoing lung cancer surgery, but there is not sufficient evidence about the application time of exercise required to ensure effectiveness.[20] However, regardless of the duration of application, it is known that early mobilization in the postoperative period reduces pulmonary complications, morbidity and mortality and shortens the length of hospital stay. Mobilization exercises should be planned by taking

into account factors such as the type of surgery, the patient's age, the patient's comorbid diseases, and the patient's general condition. The aim is to prepare a mobilization program ensuring that patients can get out of bed as early as possible. Thus, in addition to improving pulmonary functions, many additional benefits such as the transition to oral nutrition in the early period, reducing pain, preventing wound infection, returning to daily life activities faster, and preventing deep vein thrombosis can be obtained. For the success of this planning, patients should be actively included in the team, in addition to nurses, doctors and other healthcare professionals. It is known that the pedometer application also contributes to the active role of patients in this planning, thus contributing to their early mobilization.[21,22]

In the study, the mean step count for the postoperative 4 days was determined as 1594.3±1204 step and the walking distance was determined as 3260±2270 m. In the study carried out by Esteban et al., it was reported that patients who underwent anatomical lung resection with a minimally invasive technique walked an average of 8143±1708 steps and the mean walking distance was measured as 5800±1200 m postoperatively.[17] Nakajima et al. revealed that 62% of the patients who underwent hepatopancreatobiliary surgery took 5,000≥ daily steps and the mean step count per day was 6,174.[22] Porserud et al. reported that the step count was higher in patients who underwent abdominal cancer surgery and were followed up with an activity monitor compared to patients who were not followed up (1,057 versus 360).[6] In their systematic review, Memon et al. revealed that the low daily step count (1,000 step) adversely affected surgical outcomes.[11] Kavurmaci et al. showed that the step count below 2,513 on the 1st postoperative day in patients who underwent lung resection other than pneumonectomy was associated with prolonged air leak.[10] Takahashi et al. showed that the daily mean step count threshold of 1,308 steps in patients who were rehospitalized for cardiac reasons after cardiac surgery was a risk factor.[23] It is stated that patients undergoing lung resection cannot return to their preoperative physical activity levels in the 2nd month postoperatively.[24] Pedometers can be used to monitor mobility and detect patients at risk for poor surgical outcomes early.[25] The study results reveal the importance of monitoring postoperative physical activity, but the postoperative step count in lung resections may be lower than in other surgical patients.

In the study, it was determined that there was no correlation between the total step count and the total walking distance and FEV_1, FVC and FEV_1/FVC values in the early postoperative period. Likewise, Edvardsen et al. revealed that the FEV_1 values of the patients who did high-intensity training after lung cancer surgery did not change after the intervention compared to patients who did not.[26] Jonson et al. reported that FEV_1 and FVC scores did not differ between active and sedentary patients 2 months after cardiac surgery.[12] In a meta-analysis with the sample consisting of patients undergoing lung resection, it was reported that exercise training improved exercise capacity but had no effect on FEV_1 values.[27] Although studies show no positive effect on lung capacity in the early postoperative period, the effect of physical activity on body health is obvious, and it is important to encourage patients by healthcare professionals in the early postoperative period.[28]

As the total step count and walking distance increased, it was determined that the length of postoperative hospital stay decreased, while Nakajima et al. found that the length of postoperative hospital stay was shorter in patients who underwent hepatopancreobiliary malignancy surgery with a good preoperative daily step count.[22] In their systematic review, Abeles et al. detected a negative correlation between physical activity and length of postoperative hospital stay.[29] Porserud et al. indicated that patients with a high activity level in the postoperative period had a shorter length of hospital stay after abdominal oncologic surgery.[6] Daskivich et al. determined that the step count <1,000 on the postoperative 1st day prolonged the length of hospital stay.[30] The study findings demonstrate that the increase in the postoperative activity level has a positive effect on the length of postoperative hospital stay.

It was determined that 84.6% of the patients were satisfied/very satisfied with the use of a pedometer. It was revealed that the total step count of the patients who were satisfied/very satisfied with the

use of a pedometer was higher than those who were not satisfied. Danner et al. determined that patients with bipolar disorder were highly satisfied with the use of a pedometer.[31] Pedometer-based interventions to increase physical activity in people with chronic paralysis were reported to be pleasing (80%).[32] It is stated that pedometers have an activating feature for individuals with their visual feedback feature.[33] Additionally, patients think that pedometers increase motivation for exercise and provide benefits to their health.[31] Another study determined that 93.7% of older adults would recommend a gait intervention to a friend, which included a pedometer, educational material, and group discussions.[34] Mendoza et al. revealed that the step count in the group followed with a pedometer was higher than the control group followed with a diary at the end of 3 months among patients with COPD.[35]

LIMITATIONS

The most significant limitation of the study is the small sample size and the fact that data collection was performed in a single center. The pedometer used in the study was not formally validated in surgical patients. However, it is observed that the step count evaluated by the pedometer increased every day, it encouraged patients to walk and contributed to pulmonary rehabilitation. Another limitation is that the data were on the early postoperative period. At this point, further research is needed.

CONCLUSION

The study demonstrated that the increase in the step count was not effective on pulmonary functions in the early period but shortened the length of postoperative hospital stay. It was determined that the use of a pedometer was welcomed by the patients and encouraged a faster return to daily life activities by increasing physical activity. We recommend the use of a pedometer after lung resections since it standardizes the mobilization measurement, promotes mobilization, and shortens the length of hospital stay owing to its contributions to pulmonary physiotherapy. However, there is a need for randomized-controlled studies with larger case series on the subject.

Data availability statement

The data that support the findings of this study are available from the corresponding author, [ZKÖ], upon reasonable request.

Source of Finance

During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.

Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

Idea/Concept: *Zeynep Kızılcık Özkan, Ayşe Gökçe Işıklı, Seher Ünver, Fazlı Yanık;* ***Design:*** *Zeynep Kızılcık Özkan, Ayşe Gökçe Işıklı, Seher Ünver;* ***Control/Supervision:*** *Zeynep Kızılcık Özkan, Ayşe Gökçe Işıklı, Seher Ünver, Fazlı Yanık;* ***Data Collection and/or Processing:*** *Ayşe Gökçe Işıklı, Fazlı Yanık;* ***Analysis and/or Interpretation:*** *Zeynep Kızılcık Özkan, Seher Ünver, Fazlı Yanık;* ***Literature Review:*** *Zeynep Kızılcık Özkan, Ayşe Gökçe Işıklı, Seher Ünver, Fazlı Yanık;* ***Writing the Article:*** *Zeynep Kızılcık Özkan, Ayşe Gökçe Işıklı, Seher Ünver, Fazlı Yanık;* ***Critical Review:*** *Seher Ünver, Fazlı Yanık;* ***References and Fundings:*** *Zeynep Kızılcık Özkan, Ayşe Gökçe Işıklı, Seher Ünver, Fazlı Yanık;* ***Materials:*** *Zeynep Kızılcık Özkan, Ayşe Gökçe Işıklı, Seher Ünver, Fazlı Yanık.*

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