

Influence of reduced pressure and physical restraints on pre-mortem tissue swelling which some times results in blood clots. Experiment II

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Abstract – The influence of reduced pressure on the circumference of foot, ankle and calf was evaluated. Two treatments (sock vs. restraint or support hose) were compared at each airport and at flight elevation. Circumference of the foot, ankle and calf were measured for each evaluation. The data was statistically analyzed for both short and long as well

as combined flights. For all flights, and all locations, the lower leg swelled. This swelling was found to be significant for long flights and combined flights for the calf. This would suggest that the restraint is valuable for reducing calf volume under decreased pressure.



Heat sealed plastic not vacuum packaged at airport



Heat sealed plastic swollen at altitude



Bottle capped at altitude



Bottle collapsed at airport

Figure 1. Visual comparisons between objects at the airport and altitude (2 left photographs) and between altitude and airport (2 right photographs)

I. INTRODUCTION

Over 300 million passengers travel each year on long-distance flights (Brenner [4]). High risk passengers for DVT (deep venous thrombosis) include those having previous VTE (venous thromboembolism), known thrombophilia, major surgery within previous 6 weeks, malignancy or family history of VTE, taking estrogen, varicose veins, older age, factor V Leiden mutant ion, joint problems, obesity, inherited or acquired hypercoagulability. This risk increases exponentially with longer duration of travel (> 8 hour flight causes an increase), window or central seats, which suggests that that this problem is a multi causal disorder. A flight as short as 1 hour

reduces venous return from legs and leads to local hemoconcentration. A 12 hour flight can lead to swelling and fluid retention which might be expected to confer a thrombosis risk (Watson [10]). In spite of limited research there seems to be only a weak relationship between air travel and VTE but this relationship increases in flyers with increased risk factors and length of flight (Chee [6], Arval [2]). These authors also suggested that future studies are important as the public health concerns are significant. When an aircraft climbs usually to 1500 to 2499 meters the air pressure inside the cabin decreases and air and other gases expand by approximately 30%. These changes do not cause any problems where gas movement can take

place freely, but may cause discomfort or damage when gas is trapped or restricted. Graduated compression stockings {GCS, hosiery; ankle has the greatest pressure, which gradually decreases up to the calf (Agu [1])} are often utilized to prevent flight-related (flight associated, economy class syndrome, coach class thrombosis, flight thrombosis, and travelers thrombosis) thrombosis. The influence of the reduced pressure was not explored until flight-related thrombosis was perceived as a preventable illness. However, the effectiveness of GCS in preventing flight-related thrombosis remains unresolved (Hsieh [7]). This problem is believed to be exacerbated by limited leg space, which can result in compression of veins, especially the popliteal vein (Belcaro [3]) and therefore, reduced calf muscle pump efficiency (Chee [6]). To reduce flight deep vein thrombosis, the most commonly accepted method is the use of external-compression for the prophylaxis of flight-related thrombosis (Byrne [5], Watson [10], Chee [6]). Other intervention recommendations often include standing and moving legs for 5-10 minutes/hour, avoiding baggage between seats, and drinking water regularly (100-150 ml every hour). The results of studies on the effect of GCS ranges from no significant difference from the control to GCS being more effective than no GCS in preventing DVT regardless of the level of risk for DVT (Heish [7]). Several reports suggest that elastic stockings are advised for reducing the rate of DVT (Brenner [4], Scurr [9]). Stockings can alleviate edema which is common during long flights. Edema can be measured by the lower leg circumference. Taking the total reported literature, more studies reported a positive effect than no effect and none reported a negative effect of wearing GCS. No participants in any trials reported complaints or side effects from wearing below the knee GCS and they had good tolerability. A summary by Heish [7] indicated that the application of below-knee GCS significantly decreased the occurrence of DVT but not SVT (other reports in the review indicate it is useful) in long-haul air travelers. Most healthy people when taking long flights experience some swelling of the legs. The airlines recommend exercises and walking to help alleviate this problem; however, it is well known that a closed

container will expand when exposed to reduced pressure. After surgery, elastic surgical hose are often used to retard leg swelling. A literature review by Agu [1] examined graduated compression stockings in terms of action, efficiency and complications and recommended that the below-knee rather than thigh-length stocking be used on the basis of equal effectiveness, improved use, patient tolerance and lower cost.

II. MATERIALS AND METHODS

Experiment 1 (Ockerman [8])

Experiment 1 reported in 2013 at the ICoMST in Izmir, Turkey.

Trial 1: A restraint was placed on one leg and a sock on the other. In all locations swelling was reduced significantly or almost significantly.

Trial 2: It could be argued that the body is a closed system and the treatment of one leg might influence the other. In the second trial the same individual using different treatment sequences was evaluated. A restraint was placed on both legs outward bound and a sock was used on the inward bound flight. Even though the restraint meant reduced circumference at all locations for the foot and ankle, the differences were not large enough to be significant. The calf circumference however was significant.

The order of swelling for Experiment 1 was foot, ankle and calf. The elastic restraint retarded swelling at each location and the greatest reduction was in the order calf, ankle and foot. This research suggests that GCS statistically reduces edema on long distance air flights for an individual with medium risk factors. Some swelling occurred in all locations for both restraint and sock treatments and for both short and long flights.

Experiment 2

In Experiment 2 the same individual used a restraint on both legs on the outward bound flight and socks on both legs were worn on the return flight. The flights were also divided into short flights (less than 3 hours) and long flights (more than 3 hours). Also in Experiment 2 since the airports were at different elevations, the difference between the circumference (altitude-airport) at the

foot, ankle and calf were reported instead of the total circumference as was done in Experiment 1.

III. RESULTS AND DISCUSSION

In the current Experiment 2, for both the short and long flights, and with the socks and restraints and at all locations, the swelling differences increased at altitude compared to the airport. For short flights at all locations the decreased swellings were not significant. For long flight however the calf reduction was significant and the foot+ankle+calf reduction was also significant.

When long and short flights were combined the same significance was found. This result agrees with the results of Experiment 1. The results of Experiment 2 can be found in Table 1 and are graphically shown in Figure 2.

Both experiments would suggest that on short flights the circumference for all locations would be reduced by the restraint but not enough to be significant (this might change if more data was available). On long flights the calf swelling is reduced significantly for the restraint which is also the case when all flights are combined.

Table 1. Experiment 2 - Results of Statistical Analysis – Difference between altitude and airport measurements in centimeters

	Mean	Std. Dev	P	Mean	Std. Dev	P	Mean	Std. Dev	P
Foot(F)	0.6950	0.7658	0.2756	1.6250	0.8084	0.0742	1.1600	0.8996	0.0676
Ankle(A)	2.5913	0.3566	0.4306	1.9263	0.8418	0.0897	2.2588	0.7127	0.0865
Calf(C)	3.6963	0.6142	0.5717	5.3329	2.5594	*0.0307	4.4600	1.9262	*0.0368
F+A+C	2.3275	1.3910	0.5230	2.8583	2.2444	*0.0242	2.5872	1.8570	*0.0241

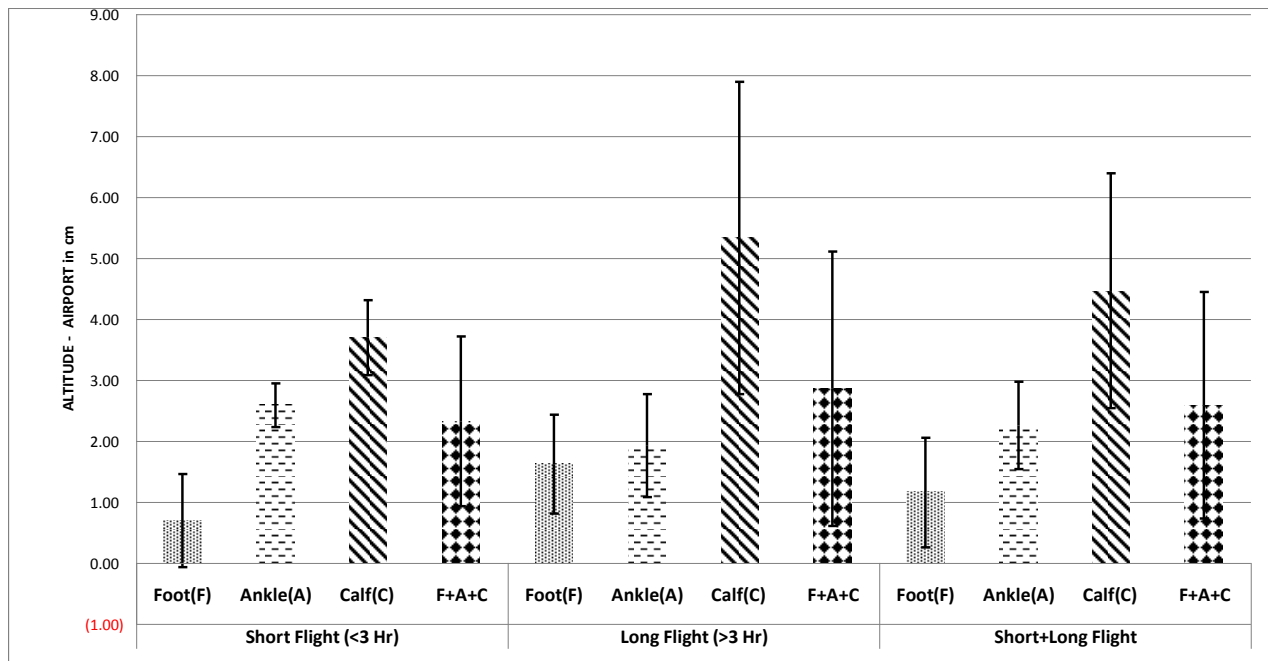


Figure 2. Mean difference in circumference (altitude - airport) for each location and for short and long flights and combined flights

CONCLUSIONS

In all cases and at all locations, restraints reduced swelling. However, this was only significant in the calf area and on long flights. Increase in sample size might result in more locations being significant.

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