CRITAC
Le Centre de recherche, d'innovation et de transfert en arts du cirque

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# North American Practices of the Russian Bar Circus Discipline: A Practical Guide

## PRACTICAL GUIDE

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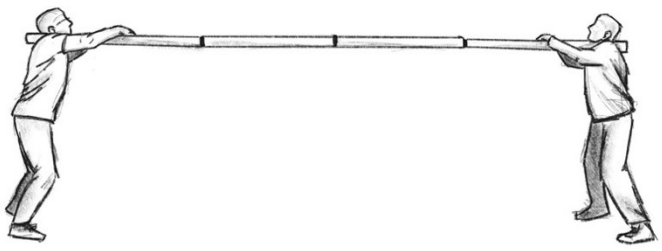

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# Introduction

## Funding

The researchers received funding from the *«Programme d'aide à la recherche et au transfert, volet innovation technologique» (PART-IT)* of the *Ministère de l'éducation du Quebec* and the *Ministère de l'éducation supérieure du Quebec* to carry out this research.


**Figure 1:** *Example of acrobats performing Russian bar | École nationale de cirque @Marie-Andrée Lemire*

## Background

The Russian bar apparatus is an acrobatic circus discipline in which an acrobat (flyer) is rhythmically propelled up in the air from the top of a long, flexible, horizontal bar of a width and length akin to the surface of a standard gymnastics balance beam (Mymard, 2016; Stewart, 2009). The Russian bar is suspended off the ground lengthwise, parallel to the floor, on the

shoulders of two acrobatic performers (porters) on each end of the bar (see Figure 1). The objective of this apparatus is to propel the flyer upwards into the air from the top surface of the bar to perform various acrobatic maneuvers and land back down on the narrow bar surface (see Figure 1). Such maneuvers on this apparatus usually begin (i.e., take-off) and end (i.e., landing) on the flyer's feet, which are in contact with the surface of the bar. However, some maneuvers and techniques that can involve various other body surfaces (e.g., flyer landing on the bar on their back or stomach with their hands and legs wrapped around the bar for stability). Common Russian bar maneuvers on top of the bar (i.e., taking off from the feet and landing on the feet) usually include jumps and saltos by the flyer in various creative body positions akin to gymnastics maneuvers (e.g., tucked, piked, layed-out). These maneuvers include somersaults, which involve rotation in either in the sagittal plane (backwards) direction, the frontal plane (forwards) direction, or on occasion in an off-axis direction. These somersaults can also include twisting in the transverse axis (i.e., left, or right) throughout the maneuver. The maneuvers are usually linked together with, or without simple jumps (referred to as "tempos") in between to form an acrobatic sequence throughout their performance. The tempo jumps can also be used to build enough height and power to perform various acrobatic maneuvers. Activities on the Russian bar apparatus require a vast amount of training for both the porters and flyers to build trust, strength, and aerial awareness to safely conduct maneuvers (Stewart, 2009).

Although impressive, the Russian bar is a risk-prone circus discipline (Stewart, 2009). Despite both the impressive nature and risks of this apparatus, documented research about the Russian bar apparatus is scant. To our knowledge, the practical considerations documented for readers interested in the Russian bar apparatus are yet to be published in North American based circus research literature. Furthermore, the only documented practical guide was published by the European Federation of Professional Circus Schools (FEDEC) over a decade ago[1] (FEDEC, 2009; Stewart, 2009). Although the FEDEC guide is still useful, circus apparatus practices can evolve over time and the FEDEC practical guide does not account for this evolution, thus lacking a more contemporary snapshot of North American Russian bar practices.

***Objectives***

Considering the paucity in North American circus research pertaining to the Russian bar circus discipline, we sought to document a general understanding of this impressive specialty. Therefore, the overall aim of our current study is to document a snapshot of the latest preferred North American practices of the Russian bar apparatus. Development of this practical guide was by route of problem-centered interviews (Döringer, 2020). These interviews allowed us to obtain an implicit expert perspective from various professional standpoints, all of which have extensive experience in the Russian bar discipline (e.g., porters, flyers, coaches, and riggers) in North America. After the interviews, the transcripts underwent an analytic process known as evolved grounded theory, where their content was organized into the axes of Russian bar practices, as depicted in this practical guide (McCreaddie & Payne, 2010).

[1] FEDEC Russian bar guide (2009): http://www.fedec.eu/file/245/download

In addition to the implicit expert perspectives obtained, we also set out to document the process of Russian bar construction. This process was completed after focus groups compiled a series of recommended practices, then experts and researchers fabricated a Russian bar using said practices. This exercise allowed us to create an instruction manual of the fabrication of a Russian bar.

Finally, we sought to examine various Russian bars that were used by many of these same experts we interviewed via mechanical static flexion tests. The Russian bars tested include apparatus from the following organizations: École Nationale de Cirque in Montréal (ENC), Cirque du Soleil (CDS), Machine de Cirque (MDC), Cirque Barcode (BC), and 7 Doigts de la Main (7F). Ten Russian bars were tested for our study, using the static flexion test method for our study. Using this strategy, we sought to explore the specific mechanical properties of various Russian bars. These tests had the goal of determining a suggested range of what is the acceptable flexion of Russian bars, along with other preferred properties of the apparatus in the current professional atmosphere of the Russian bar practice in North America.

The information disclosed in this report is representative of the current Russian bar practices in North America, in 2023. As such, Russian bar practices might differ depending on contextual circumstances. ***Importantly, this document is not intended to be a scientific article, nor is it intended to be the singular source of recommendations for safely and effectively learning and practicing the Russian bar apparatus. This document should not be used in lieu of guidance and presence of an experienced coach in the Russian bar discipline, alongside proper accoutrements to ensure acrobats' safety on this apparatus.*** Additionally, the topics discussed in this practical guide (e.g., practices of this discipline, technical specifications, suppliers, and flexion of the bars tested) are solely for information purposes. In reference to our second aim, determining a succinct link between the mechanical properties (i.e., deflexion) of the Russian bars tested and the associated performance for acrobats would require further rigorous scientific analysis, and is above the scope of our present study. As such, this document should be interpreted with caution. We hope that creating this practical guide can provide a useful basic framework for those interested in becoming involved further with the Russian bar apparatus. Furthermore, documentation of this practical guide could be used as a basis for further research, specifically towards improving acrobatic performance and minimizing injuries sustained by acrobats due to this discipline.

## Methods

### Practical guide methods

#### *Participants*

The participants (n = 10) recruited included four acrobatic performers that currently or previously identified as acrobatic flyers ("flyers"), three acrobatic performers that currently or previously identified as acrobatic porters ("porters"), one circus technical rigger ("rigger"), and two acrobatic coaches that currently are or have previously coached the Russian bar apparatus. Implicit expert perspectives were obtained via non-directive, unstructured interviews (i.e.,

problem-centered interviews; Döringer, 2020). Participants (Russian bar experts) were recruited via purposive sampling, via the principal researchers' professional connections with CRITAC, École nationale de cirque and their colleagues in the professional circus performance industry.

***Problem-centered interviews***

The implicit expert perspectives were obtained from participants by route of problem-centered interview method outlined by Döringer (2020). The interviews conducted for this study were primarily one-on-one with the principal researcher, with a notable exception of an experienced Russian bar trio (two porters and one flyer) who opted to interview together as a group. The interviews centered around the experts' perspectives, opinions, and best practices of the Russian bar circus apparatus. The premise of the open-ended questions asked during the nondirective, problem-centered interviews were meant to engage experts with a motive or goal, but allowed the experts to guide the course in which the interview unfolds. The motive of the interview direction can be seen as; through the process of the interview, if the researcher and expert were creating a practical guide of their discipline together. As such, this operation can be seen as building practical knowledge from the ground up. The interview discussion topics centered around: The materials used to make the Russian bar, proper construction, setting up a facility to train the Russian bar, training of the Russian bar, and information regarding safety. As such, we grouped the interview in the following axis of discussion: 1) Technical information, 2) proper use and care, 4) safety considerations, and 5) general considerations for acrobats, coaches, and the acrobatic figures being performed on the apparatus. Interviews were conducted via a hybrid of in-person or virtually, according to the participant's preference and availability. Field notes were taken by the interviewer during the interviews, along with maintenance of a research journal.

***Focus group construction***

While interviewing experts, it quickly became evident that explaining the process of building the Russian bar without a tangible example unearthed a lack in the depth of information that could be gathered about effectively constructing a Russian bar from the various components. As such, after the problem-centered interviews concluded, three participants (one rigger and two coaches) took part in a focus group activity, alongside principal researcher to construct a Russian bar and describe the process (for information about focus groups as a research method, see Denny & Weckesser, 2022). Such an activity allowed us to tangibly present, in this guide, the process of effectively constructing a Russian bar apparatus.

***Data treatment and analysis***

Both the interviews and the focus group activity were audio and video recorded, then transcribed in-verbatim (with filled pause words removed for clarity) for data analysis. The interview transcripts were analyzed by route of a technique known as evolved grounded theory, proposed by McCreaddie and Payne (2010). This qualitative analysis technique is a useful method to probe a particular topic, phenomenon, or process that has yet to have a well-established theoretical framework to ground it in. Such a technique uses the collected data from in-depth interviews to develop a working theory. Evolved grounded theory lends well to studying the Russian bar

apparatus, considering the minimal practical information that is not yet well established in research literature. Specific to our study, however, the intention was not to develop a working theory per se – we intended to **obtain a snapshot of the common practices and perspectives from experts in the Russian bar apparatus**.

The evolved grounded theory analysis technique we used is an iterative process (McCreaddie & Payne, 2010). The iterative nature of this analysis technique is such that after a given interview was conducted and transcribed, the process of coding begins on that transcript. During the analysis of this first interview transcript, the subsequent interview can take place. The iterative cycle continued until the interviews were concluded for this study.

### *Rigor and reliability of qualitative data*

The content from the interviews conducted and proposed practices in this practical guide were member-checked to ensure rigor and accuracy of information (Birt et al., 2010). Member-checking was done by calling participants to additional meetings to read drafts of this practical guide and discuss any points requiring amendment or further research by interviewing experts. The process of member-checking helped us ensure that the content in this practical guide is aligned with the opinions and recommendations of the experts interviewed. Practices included in this guide that were debated or noted as inaccurate by experts sampled were either adapted, eliminated, or noted as variable across expert opinions in the results. Such a process ensured accuracy of the recommended North American practices of the Russian bar discipline reflected in this guide.

## Static flexion test protocol

### *Russian bars tested*

**Table 1**

*General information of the Russian bars tested (ENC: École nationale de cirque, CDS: Cirque du Soleil, MDC: Machine de Cirque, 7D: 7 Doigts de la Main, and BC: Barcode)*

| Bar | Owner | Length (m), (ft) | Pole diameter (mm), thick-ness (mm) | Pole supplier, model, composition | Additional information |
|---|---|---|---|---|---|
| ***1*** | ENC | 5.026, 16.491 | 38mm, 2mm | UCS, Spirit[2], GFRP | Built approx. 2017(N/A who), antiparallel config., gaffer[3] & hockey tape, silicone |
| ***2*** | ENC | 4.915, 16.126 | ~34mm, 2mm | N/A | N/A |
| ***3*** | CDS | 5.029, 16.501 | N/A | N/A | N/A |

[2] GFRP (Glass Fiber Reinforced Polymer) *spirit* manufacturer: https://www.ucsspirit.com/products/vaulting-poles/spirit-poles-selection/spirit-vaulting-pole

[3] Gaffer tape manufacturer: https://echotape.com/products/cl-w6033-matte-black-professional-gaffers-tape/

| | | | | | |
|---|---|---|---|---|---|
| ***4*** | CDS | 5.037, 16.527 | N/A | N/A | N/A |
| ***5*** | CDS | 5.032, 16.509 | N/A | N/A | N/A |
| ***6*** | MDC | 4.295, 14.091 | N/A | Gill Porter, Pacer[4], CFRP | N/A |
| ***7*** | 7D / BC | 4.270, 13.123 | ~ 37mm | Gill Porter, Pacer fxv[5], CFRP | *BC* built (2011/2012), hockey tape, no silicone (like FEDEC) |
| ***8*** | 7D / BC | 4.270, 13.123 | ~ 37mm | Gill Porter, Pacer fxv[6], CFRP | *BC* built (2011/2012), hockey tape, no silicone (like FEDEC) |
| ***9*** | BC | 5.000, 16.400 | ~ 40mm | UCS, Spirit[4], GFRP | BC built (2010/2011), hockey tape |
| ***10*** | ENC | 5.026, 16.491 | 38mm, 2mm | UCS, Spirit[4], GFRP | ENC built (2023), antiparallel config., hockey tape, silicone |

Photographs of nine of the ten Russian bars that underwent static flexion testing can be found at the end of this report (see Appendix A). There is a considerable amount of information missing regarding the various bars tested (reflected in Table 1, as "N/A"). The most notable missing information is in reference to the bar diameter, the origin of the bars, purchase date, and supplier information of the poles that many of the tested Russian bars are made from. Some organizations that own the Russian bars for testing were unable to provide this information, and their missing data made interpreting static flexion test results cumbersome. In addition, comparing how the bars flexion can differ depending on the diameter and supplier of the bars posed to be equally cumbersome. Accordingly, we encourage the reader to interpret the static flexion test results with discretion.

For the focus group activity, experts worked with our team of researchers to construct a Russian bar from its various components, discussing the recommended practices throughout the process. We opted to purchase three new *Spirit* poles manufactured by UCS[6] to construct the Russian bar (bar number 10 in Table 1). The construction of this Russian bar was done over the course of two days with the primary researcher working with three experts in an interactive focus group setting. Construction of this Russian bar from the various components benefit our project in two ways: 1) by providing context to personify the best practices of constructing a Russian bar, and 2) by creating an opportunity to conduct a static flexion test on the bar prior its first use by acrobatic performers. Thereafter, we repeated the static flexion test protocol of the newly constructed bar at different time intervals of normal use. This series of static flexion test results can be analyzed to compare flexion as the Russian bar was trained on, which could provide insight on how this

[4] CFRP (Carbon Fiber Reinforced Polymer) *pacer* manufacturer: https://www.gillporter.com/gill_store/pacer-composite-vaulting-pole.html
[5] CFRP (Carbon Fiber Reinforced Polymer) *pacer fxv* manufacturer: https://www.gillporter.com/gill_store/pacerfxv-vaulting-pole.html
[6] https://www.ucsspirit.com/products/vaulting-poles/spirit-poles-selection/spirit-vaulting-pole

apparatus' flexion can change with increased use. The result of the change in flexion as the bar gets ''broken in'' can be seen by comparing the newly constructed Russian bar 10 to Russian bar 1 (in Table 1) since both use the same poles and construction method. We assembled the bar on the 17th and 18th of February 2023 at École nationale de cirque in Montréal, in a workshop designed for constructing circus equipment. The process of assembling the Russian bar is depicted below (see "Constructing a Russian bar").

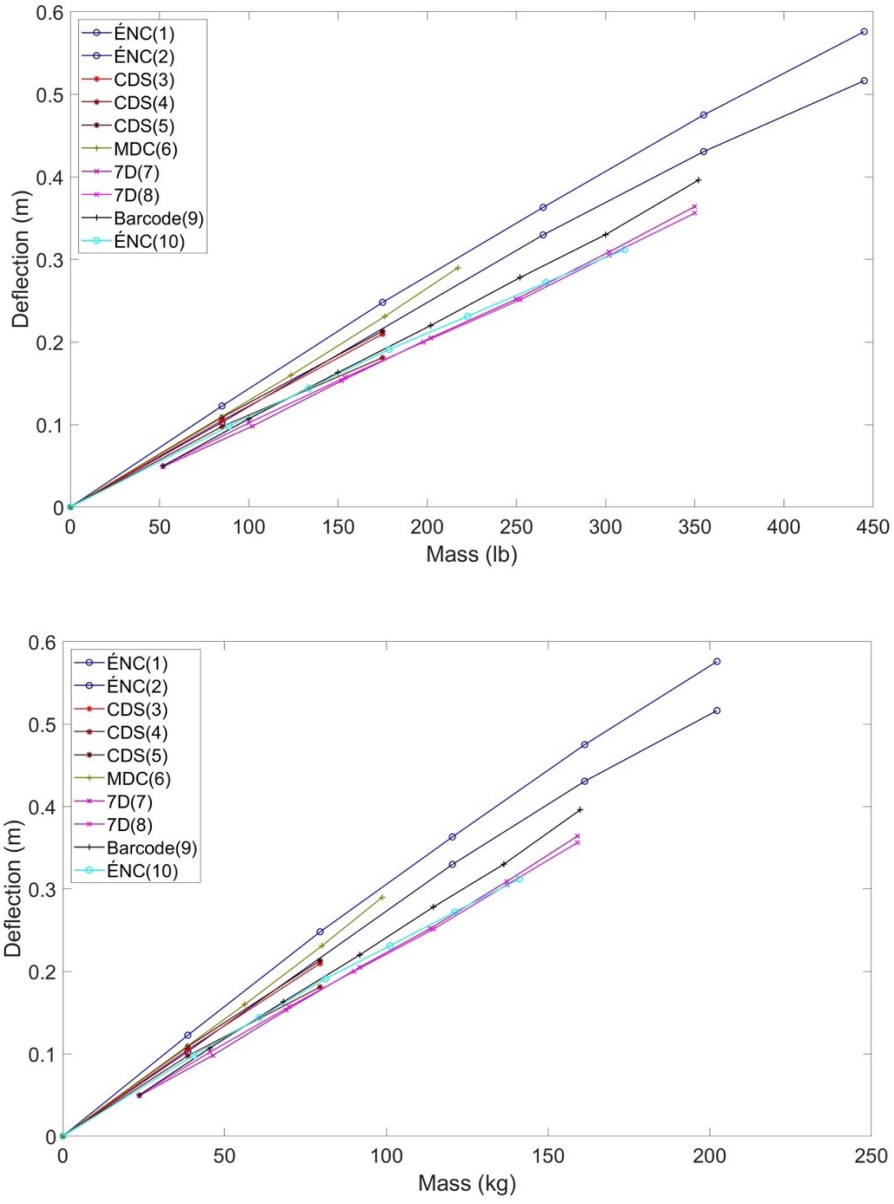
**Static flexion tests**

The static flexion tests took place at different locations based on the availability of facilities of the various organizations affiliated with this project. Russian bars 1, 2, 3, 4, and 5 were tested at *INEDI* industrial design research center in Terrebonne, Quebec. Russian bars 6, 7, 8, 9, and 10 were tested at their place of origin (i.e., *MDC* for bar 6, *7D* for bars 7, 8, and 9, and *ENC* for bar 10). The available equipment differed slightly at each location. As such, the test protocol differs slightly depending on location (for information regarding the specific test protocol, see Appendix B). Regardless of location and differences in equipment used during the static flexion tests, the principles and objectives of all trials throughout this study remain the same. The intent is to simulate flexion by suspending the Russian bar between two supports while hanging weights from the middle (simulating the weight of a flyer). We then measured the deflection of the bar while adding increasing weights. Depending on the location of the test, different methods of weight simulation were used: Standard barbell weights (*INEDI* and *ENC*), floor anchoring points (*7D),* and human beings' weight (*MDC).* Each Russian bar tested was held on supports at each end, at approximately the same location where the porter's shoulders would be (i.e., approx. 10cm from the end of the Russian bar). In addition to this protocol, we also obtained two additional measurements from Russian bars 1, 2, 3, 4, and 5 at *INEDI*. These additional measurements include: 1) Motion capture of the curvature of each Russian bar, and 2) the force pushing down at each support end. For the sake of simplicity, we do not present the results and interpretation of these additional measurements in this report, but they will reappear in a further study.

## Static Flexion Test Results

**Figure 2**

*Results of various Russian bars' deflection as a function of its center mass (lb above, kg below)*

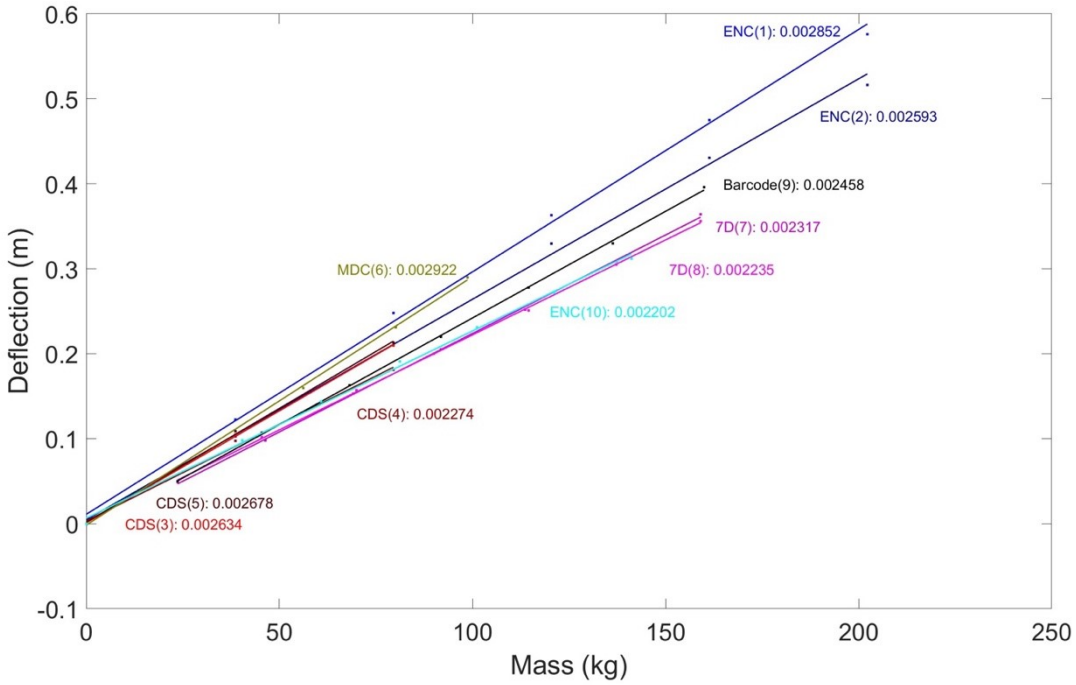



The point of zero deflection was set, as a control, to the curvature of the Russian bar with no applied load (i.e., mass added). Noting the curvature of the bar without applied weight allowed us to compare the elasticity of the Russian bars tested. Interestingly, Russian bars tested at their rest position varying curvatures, even with no applied load. The maximum deflection measured was 57.6 cm for a mass of 202 kg (445 lbs), which was observed testing Russian bar ENC(1). For sake of comparison, we measured a maximum deflection of approximately 100cm while

conducting a dynamic test with an acrobat jumping on Russian bar ENC(1). We opted to avoid reaching this critical value to avoid damaging the Russian bars, given the difference between static and dynamic tests in performance of this apparatus. The deflection curves (shown in Figure 2) seem to follow a linear trend for all Russian bars tested. The few data points in the deflection curves that seem to deviate from this trend could be present due to measurement errors or uncertainties due to different measurement protocols that occurred at each facility.

**Figure 3**

*Linear trendline of bar deflection compared to mass of the Russian bars that underwent testing*

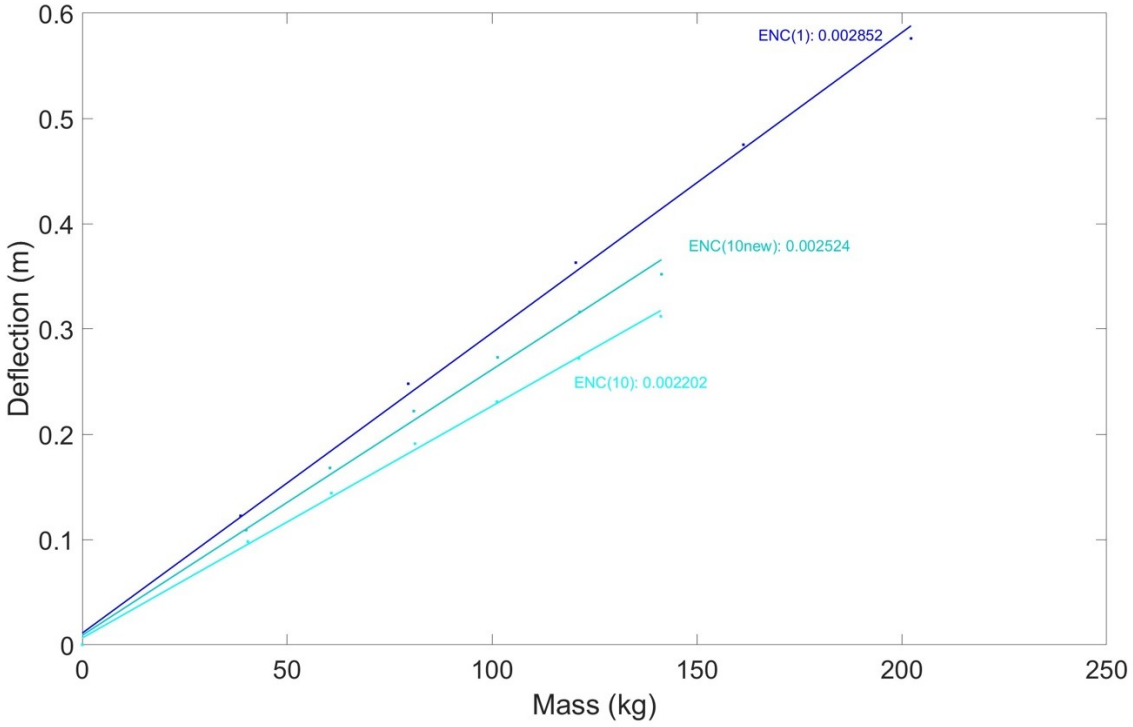



*Note: The amount after each Russian bar name indicates the slope of each trendline (in m/kg)*

Figure 3 shows the linear trend for all ten Russian bars tested. The slope value shown in this figure reflects the elasticity of the bar; with a higher slope value indicating a bar that deflects more. The slopes calculated range between 0.002202 m/kg for ENC(10) on the low end and 0.002922 m/kg for MDC(6) being the highest value. Consider a scenario in which we use the same mass: 350kg for example (an acrobat of 60kg with a dynamic factor of 6 generated during dynamic movement). Using this applied force, we would obtain a deflection at the center of 0.771m for ENC(10) and 1.023m for MDC(6). Using the slope value, we can predict the deflection of each bar using the mass of the applied force.

**Figure 4**

*Linear trend curves for the ENC Russian bars with acrobatic use throughout time*




Russian bar ENC(1) has been used at ENC for approximately 5 years. ENC(10new) is brand new, constructed based off the model of ENC(1). This bar underwent static flexion testing just after it was constructed during the focus group activity. Russian bar ENC(10) refers to the Russian bar ENC(10new), which underwent static flexion testing after students at ENC used the Russian bar for several trainings. Reflected in Figure 4, the ÉNC(10) bar is stiffer than when it was tested after its manufacture ENC(10new). It is interesting to note that, compared with the Russian bar ENC(1) which was the reference model for building ENC(10) for the purposes of this study, both ENC(10) and ENC(10new) are stiffer than ENC(1).

# Russian Bar Practical Guide

*Disclaimer:* The following tenets are an accumulation of information from the experts interviewed. This practical guide is not an exhaustive depiction and is considered preliminary information. As such, this guide should be read for informative purposes and should thus be interpreted with prudence and assumed as anecdotal until further rigorous studying is conducted.

## Technical information

### *Three-pole Russian bar*

The Russian bar is typically composed of three pole vaulting poles used in track and field (hereby referred to as a "poles"), adhered together to create one functional unit (hereby referred to as a "Russian bar"). Although there are other variations of the Russian bar apparatus that use a single pole or two poles, these variants are beyond the scope of this discussion and do not serve the purpose of this study (as discussed in the FEDEC Russian bar guide; Stewart, 2009)

**Pole composition.** Two primary materials (fabricated by two separate suppliers) can compose the poles, and there are noted benefits and drawbacks to using either material. Below is some practical information about the two primary pole materials, along with the recommended suppliers:

***Option 1: GFRP.*** Glass fiber reinforced polymer (GFRP) composite is the recommended option for high intensity use in pole vaulting applications (Davis & Kukureka, 2012). Most participants interviewed prefer GFRP as a material for their Russian bar, citing that it is preferred because they are capable of a greater amount of flexion and can result in the flying acrobat being propelled to a greater vertical height. Additionally, porters interviewed discussed these types of Russian bars as being more user-friendly and maneuverable, likely due to the increased flexibility experienced when compared to composite Russian bars. Russian bars composed of GFRP poles are noted by participants to be more fragile and can be more prone to breakage. Furthermore, this material has been known to fail if the flying acrobat is too heavy for that specific pole rating. Despite the drawbacks, most experts noted their preference for using these poles. Experts noted that GFRP bars can be purchased from the manufacturer called UCS Spirit (Davis & Kukureka, 2012)[7].

***Option 2: CFRP.*** Carbon fiber reinforced polymer (CFRP) composite is another option (Davis & Kukureka, 2012). Participants interviewed reported that Russian bars constructed with composite poles were not preferred. Interestingly, Russian bars composed of CFRP poles were noted to be more robust, lighter, and less prone to breakage. Furthermore, composite poles can be made longer and stiffer compared to GFRP (Davis & Kukureka, 2012). However, because composite poles are constructed with carbon fiber (epoxy laminated layers of carbon fabric), this

[7] https://www.ucsspirit.com/products/vaulting-poles/spirit-poles-selection/spirit-vaulting-pole

material has been known to be stiffer and more resistant to bending, yet more prone to breakage and microfractures when under high bending force compared to GFRP (Burgess, 2020).

**Pole rating.** Each pole is rated based on the weight of the pole-vaulting athlete in the context of track and field. Similarly, when constructing a Russian bar fusing these same poles, one must consider the rating of the poles and how this can impact the bar's dynamics while traingin and performing. The appropriate rating range of poles used in a construction of an efficient Russian bar were discussed by experts as being between 150lbs and 200lbs. The preference of which pole rating was concluded to be dependent on: 1) The weight of the flying being propelled, 2) the type of acrobatic maneuvers that they specifically do, and 3) the preferences of porters and their flyer. The majority of experts emphasized the benefits of using GFRP (highlighting the drawbacks of using CFRP), while also preferring Russian bars made from GFRP poles rated at 195lbs. Accordingly, we chose GFRP poles rated at 195 lb to construct our Russian bar (bar number 10 in Table 1).

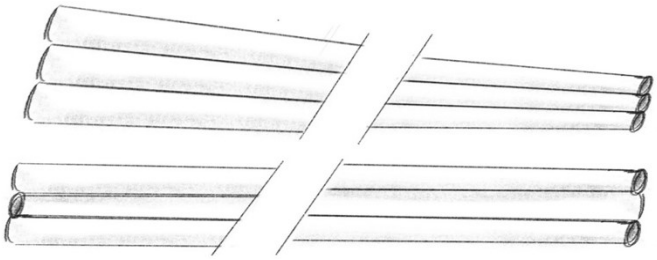
***Russian bar length.*** The length of the Russian bar, ergo the length of poles, is an equally important consideration brought up by experts. This length can vary depending on the Russian bar trio's: 1) Preferences and morphology, and 2) the acrobatic figures and maneuvers they perform. Of the lengths discussed in the interviews, an optimal Russian bar length was agreed upon at 500 cm (16'5"). Additionally, using a longer bar is recommended when learning and novice performers, while also being preferred by many experienced performers. Longer Russian bars are discussed to have slower jump responses, allowing for more adjustments mid-tempo. The slower jump response also benefits the acrobats by being more forgiving on the body due to the increased flexibility of the bar.

Accordingly, when fabricating a Russian bar, we recommend purchasing three 500cm (16'5") poles of the same rating. A shorter Russian bar is noted to result in a more rigid bar for both the flyer and porters. Shorter Russian bars are discussed to be more rigid on landings, as compared to a longer bar. This phenomenon could be explained by a lower deflection observed in the shorter Russian bars (i.e., less flexible) and thus having a quicker, stiffer jump response.

***Relative configuration of poles.*** The poles used to construct the Russian bar are slightly conic in shape. This irregular shape results in the diameter on one side of the pole being slightly larger than the diameter on the other end. The consequence of this conic shape, participants discussed, is that the point of maximum flexion is not directly at the center point of the pole. Considering that the standard Russian bar consists of three poles, the reader must make a crucial decision regarding the relative configuration of each pole (i.e., which side of each pole's conic shape should be in relation to the others). Therefore, since there are only three (conic-shaped) poles, the Russian bar pole configuration must either be:

1) *Parallel configuration*, in which the three pole diameters (i.e., large and small) match on each side, or

2) *Antiparallel configuration*, in which the middle pole diameter differs from the outer two poles.



Experts indicated preferences for both arrangements, with a slight preference for an antiparallel configuration. Such a preference is likely dependent on, body specifications, experience level, and the profile of acrobatic maneuvers that they are doing on the bar. Furthermore, participants noted that the difference in configuration can result in a differing mechanical dynamic when using the bar. For example, the point of maximal flexion (i.e., where the bar flexibility is greatest) for a Russian bar constructed using the parallel configuration is often not in the exact center of the length of the bar. The point of maximal flexion is discussed to be somewhere slightly towards the front porter (i.e., anterior). Conversely, the point of maximal flexion of the antiparallel configuration is noted to be closer to the center of the length of the bar, when compared with the parallel arrangement. The antiparallel configuration could therefore be a more optimal solution, should the Russian bar acrobats require a more flexible and forgiving bar for their acrobatic maneuvers.

***Taping.*** The adhesion of the three poles together to create a singular Russian bar is done primarily using a series of adhesive tapes, which are looped around the bar in a particular pattern, sequence, and direction. Of the popular adhesive tapes noted, the primary tape used is 24mm (wide) "*pro-blade cloth"* hockey tape manufactured by *Renfrew*[8], which has smooth edges rather than serrated. The smooth edges of the hockey tape are an important consideration noted by participants, citing that the serrated edge hockey tape can create more friction on the areas in which the acrobats (both flyers and porters) are in contact with. This consequence of using serrated hockey tape (particularly on the top surface) is such that the tape can roll up along its edges and create an uneven surface, while also exposing the inside of the bar.

While using physiotherapy tape in place of hockey tape is an appealing option due to its increased thickness in width, some participants cautioned against its use, noting that it is insufficient and not recommended. They indicated that this choice of tape is inferior due to its stretchy fabric and the fact that the adhesive tends to degrade over time and separate from the fabric of the tape. Should the tape adhesive begin to degrade, the separation of tape from the interface and poles of the Russian bar poses an issue for the function and safety of the acrobats. Conversely, participants noted that hockey tape adhesive tends to stay on the fabric and interface between the bar and the tape fabric more effectively. Furthermore, hockey tape is indicated to be less tacky on the surface of the bar, reducing debris sticking to the surface. A tacky, sticky surface from tape adhesive degrading can pose a risk for the performers, and result in a higher risk of skin abrasions when their body comes in contact with the apparatus. Such skin abrasions

[8] Renfrew catalogue : https://www.renfrewpro.com/docs/default- source/renfrewprodocuments/renfrewpro-productcatalogue-english-digital.pdf?sfvrsn=2

consequential to the tacky, sticky surface from some tape residue are most notable in porters, who place the bar on their shoulders. The friction creates skin abrasions, blisters, and infections if not dealt with properly. Furthermore, the adhesive surface of the external part of the bar can collect dust and change the texture of the bar's surface, which can also pose a risk to the acrobats' safety. All participants emphasized that dust and dirt pose a safety issue for the Russian bar when in contact with the adhesive tape, since this condition can create a slippery layer on the surface of the Russian bar.

***Silicone caulking.*** Participants noted constructing Russian bars using silicone caulking in the crease between poles, with the majority citing this technique as the optimal solution. Some indicated that fabricating Russian bars without silicone is possible but could require more tape. The application of silicone caulking has two primary benefits: 1) To provide a low-friction interface between the individual poles to prevent friction-related stress that could cause unnecessary wear and potentially compromise the Russian bar structural integrity, and 2) to help adhere the bars together. Accordingly, during the focus group activity, we built the Russian bar with silicone caulking.

***Foam padding.*** There are three locations where foam must be incorporated, under layers of hockey tape, in the composition of the Russian bar. The fabricator must pad these locations to coincide with where the acrobats make contact the bar (i.e., both ends for the two porters on the bar's underside and approximately 200cm along the center top portion of the bar).

**1. Center padding for flyer.** Adequate padding must be placed to ensure the comfort and safety of the flyer, who is launched up and often lands on the surface of the Russian bar. This padding should be placed in the center of the bar, such that the flyer should land any maneuvers they do on the padded surface and not on the taped, unpadded pole.

The choice of padding for the flyers surface is of utmost importance. Participants noted using ½ to ¾ inch blue camping foam as their primary choice. It is noted to have optimal support, does not lose its shape, and degrades slower than other choices. Participants noted avoiding the use of a yoga mat, which has been indicated to degrade quicker and be less supportive than camping foam. It is also noted to be more painful to land on after effecting an acrobatic maneuver.

The thickness of the padding was also discussed as being variable and dependent on preference. It was noted that the participants felt that there was a balance between *"feeling"* the bar connected to their feet and having enough padding. The agreed thickness of foam is about ½ inch, which allows the flying acrobat to "feel" the bar enough, while having enough padding to protect their body parts and avoid injury when contacting the bar at a high velocity during their acrobatic sequences.

The length of the center foam padding is another choice that can depend on the acrobat's preference and the dynamics of the bar construction (i.e., parallel or antiparallel pole configuration). The aim is to have the foam on the surface surround where the acrobatic flyer can land. Should the acrobatic flyer be doing acrobatics that spans the bar lengthwise, a longer center mat choice is optimal. This does come with a caveat, however, where the adding more

foam results in more weight added to the bar, and creates more thickness. One participant also notes that the stiffer a Russian bar is (noted as more *"springy"* and *"quicker"*), the longer the center mat could be, as the flying acrobat can traverse more length of the bar during their maneuvers in the air compared to a bar that is slower and has more flexion. Similarly, if the bar is *"softer,"* the acrobat is likely to traverse less length of the bar during their maneuvers in the air; thus, a shorter mat length is required as a landing surface.

We advise to avoid putting the padding along the entire length of the bar to avoid excess weight of the Russian bar for the porters to hold. Additionally, the added padding along the length of the Russian bar could also change the dynamics of the bar flexion by potentially making it comparatively stiffer.

The center of the center padding should be centered with the point at which the bar flexes the most (the flexion point). Thus, it is important to consider the configuration that the bar is arranged in, as parallel configuration will result in a flexion point slightly askew from the center compared to antiparallel configuration. It is also important to note that the exact placement cannot be identified in this practical guide, as it depends on the location of where the bar flexes the most.

The center foam surface should cover the entirely of the top surface of the bar. This creates a flat surface with defined edges for the flyer to land on. It has been reported that a defined bar edge (i.e., less rounded) aids in keeping the flying acrobat balanced while standing on the bar. Conversely, should the mat be placed widthwise following the contours of the round portion, this can create a surface that the flying acrobat could have difficulty balancing proprioceptively and could slip on the edge more easily exposing them to further risk.

**2. End padding for porters.** This foam padding on the bar's edges is meant to cushion the connection between the bar and the porter acrobat's shoulder. Experienced Russian bar acrobats suggested to either use two layers of blue camping foam, gymnastics roll (i.e., "truss-line") or a hollow foam pool noodle cut open lengthwise. This padding will be placed on the bottom surface of the bar to pad the porter's shoulders.

## Constructing a Russian Bar

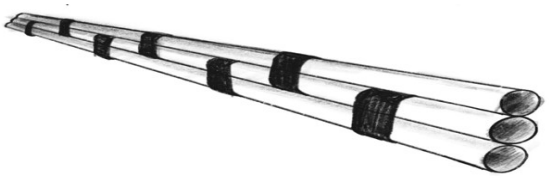
The following Russian bar fabrication instructions are based on recommended practices by the experts interviewed and the focus group activity. We must emphasize that their techniques can differ, depending on their preferences and experience. The following techniques discussed are not exhaustive but should offer a reasonable base as the participants' aggregate construction method.

In some construction steps outlined below, we included illustrations to the right for clarity. These illustrations serve as a visual aid, allowing the reader to clarify steps in the procedure that could be convoluted if explained solely via text. To begin the Russian bar construction process, ensure you are constructing the bar in a clean, dust minimized area. Experts recommended constructing the Russian bar at standard ambient room temperature (approximately 22° C). Building the Russian bar in a standard ambient room temperature with minimal potential for dust contamination is important for the adhesive elements used to properly combine the poles. We used the following materials when constructing the Russian bar as part of the focus group.

**Required materials**

- 2 stable work benches/tables of equal height (ideally on locking caster wheels)
- 3 UCS Spirit GFRP poles 500cm (16'5") length, 195lb rating recommended
- 15 rolls white 24mm wide hockey tape[9]
- 2 rolls black 24mm wide hockey tape[12]
- 1 roll single-sided clear dance floor echo tape[10]
- 1 roll double-sided echo tape[11]
- 1 high-density blue camping foam roll
- 60cm x 60cm of 1.5" thick truss-line
- 2 tubes silicone caulking (8 hour curing time)
- Silicone caulking extruder gun
- Ammonia-based window cleaner (e.g., Windex)
- Lint-free cloths
- Permanent black marker (e.g., sharpie)
- 6 large quick-release clamps
- 6 20cm x 20cm plywood squares
- 2 2 x 4 wood pieces (approx. 30cm long)
- Utility knife

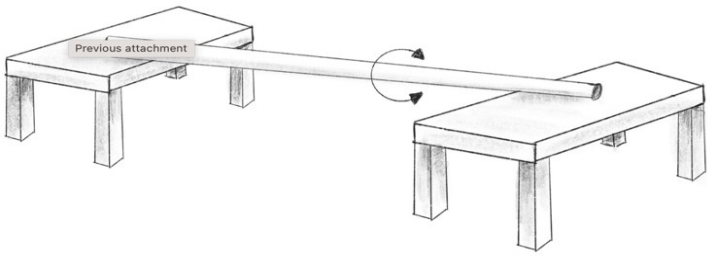
[9] Renfrew catalogue: https://www.renfrewpro.com/docs/default- source/renfrewprodocuments/renfrewpro-productcatalogue-english-digital.pdf?sfvrsn=2
[10] Echo brand tape catalogue: https://echotape.com/product-catalog/
[11] Echo brand double sided tape: https://echotape.com/products/dc-m158a-clear-double-sided-polyester-tape-for-general-purpose-mounting-bonding/



**Day 1 instructions**

**Step 1.** Remove the individual pole vault poles out of their protective packaging and place them in the desired configuration (i.e., parallel, or antiparallel). The relative front and back direction of each pole can be determined based on where the round endcap of the pole is located. This round endcap should be removed after positioning the front and back of each pole.

**Step 2.** When beginning to assemble the Russian bar, the first important task is to find the natural arc of flexion of each pole. Finding the natural arc of the pole can be done by simply placing each individual pole between two work benches at the same level and allowing the poles to roll horizontally along the work-bench surface and settle in place (i.e., stops rolling). Situate the poles such that the natural arc bend downward if suspended on each end horizontally.



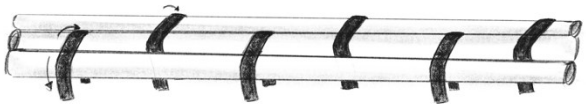

**Step 3.** After repeating this process for all three bars, use a permanent marker to mark each end of the poles denoting the "top" surface of each pole that will be used for the Russian bar assembly.

**Step 4.** Clean the pole surfaces using a lint-free cloth with window cleaner (e.g., windex) to minimize dust, hair, and debris.

**Step 5.** Clamp a 2" x 4" wood block on the workbench, perpendicular to the poles on both ends. This will ensure that each pole is aligned to the others lengthwise.

**Step 6.** Cut approximately ten 25cm lengths of hockey tape (we used black tape) to temporarilyy adhere the three poles together prior to silicone caulking. Instead of adhering all three poles together with each loop of tape, tape only two poles at a time, each successive tape loop attaching the middle pole to an alternate side (i.e., left, right alternating).

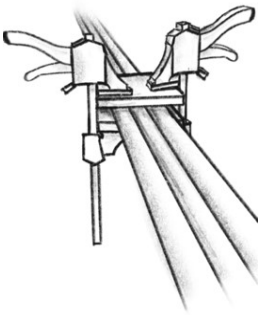
**Step 7.** The tape should be placed through the crease between the middle pole and around the round edge so that two bars are taped together, with the middle of the tape length aligned with the crease between the two.



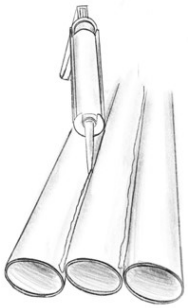
**Step 8.** Do not close the tape loop previously completed. Repeat the above taping procedure with approximately 50cm of space in between all along the length of the bar assembly. Alternate which side pole is being fixed to the center pole. Depending on the length of the Russian bar, eight to ten tape loops are recommended along the length of the Russian bar assembly. Leave the two ends of the hockey tape hanging free (i.e., not yet a closed loop of tape) until the length of the bar is taped.

**Step 9.** Once the tape loops are all in place and not yet closed, ensure that the bars are well-placed. Beginning from the middle of the bar and outwards (alternating), close the tape loops. The loop closure should be done with firm tension – first closing the inner crease end towards the outer pole, then

the outermost end toward the inside. Complete the closure of tape loops along the bar assembly, alternating sides until the end. This step is best done using multiple people to ensure the Russian bar assembly stays level and secure.

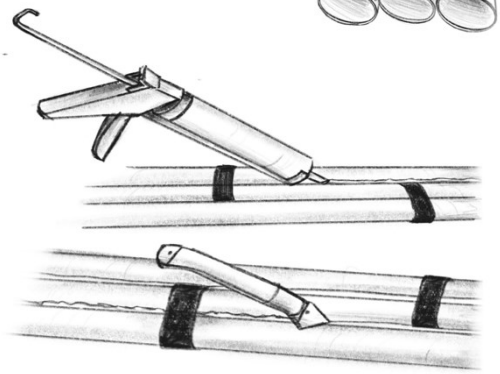


**Step 10.** It is imperative to the Russian bar assembly and its proper functioning to ensure that the top surface (for the flyer) and both ends (for the porters) of the three poles are flat relative to each other and the horizontal surface is level. Ensuring such considerations helps to avoid instabilities when acrobats use the Russian bar. Maintaining the flat surface of the Russian bar while undergoing assembly is done by using two quick release clamps on either side, so that the three poles are arranged in the center with a small plywood board at the top and bottom of the bar assembly. This clamp assembly will be used in the following steps and should use moderate clamping force to avoid damaging the poles. It is not advisable to put the clamp assembly on after the silicone is cured (day 2). Install this clamp assembly on both ends and in the center of the Russian bar.



**Step 11.** Load the caulking gun with a fresh tube of silicone caulking and cut a hole at the extruding tip as per the tube instructions. Place a small amount of silicone caulking along the length of the bar assembly, in between the grooves on either side of the middle pole.

**Step 12.** To extrude caulking underneath the tape loops, use the small opening under the tape. In this crease, there should be enough space to fit the extruding tip of the caulking in to fill with a small amount of silicone underneath the tape.



**Step 13.** Using a putty knife or a clean finger dipped in a cup of room-temperature water, even out the silicone caulking on the surface of the crease with moderate pressure and push the caulking into the crevices between the poles. Periodically dip the putty knife (or pointer finger) in water to keep the silicone from sticking to the finger or putty knife.

**Step 14.** At this important step, the clamp assemblies will need to be moved to extrude silicone caulking underneath their covered area. We encourage to change their placement as minimally as possible, one clamp at a time, allowing the other two clamps maintain the bar assembly being a flat and level bar assembly.

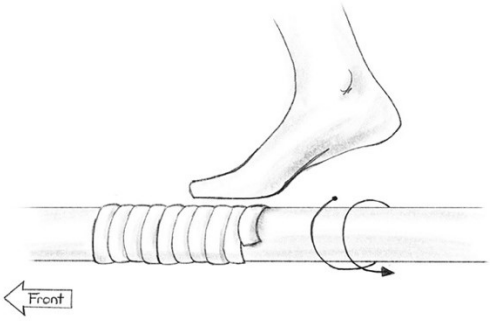
**Step 15.** After the full length of the top surface is caulked, the bar assembly should carefully be flipped using one person at each end, making sure to keep the clamps holding the three poles in place.

**Step 16.** Repeat the caulking process on the additional two creases of the bottom of the Russian bar in the same way as described in step 13. Allow a minimum of 8 hours (preferably overnight) for the caulking to cure, limiting the exposure of dust, hair, and debris while curing. Note: some silicone caulking cure times can vary. Use the curing time recommended by the manufacturer.

**Day 2 instructions**

Three important considerations related to the taping technique must be noted before proceeding:

*1. Hereon after, any mention of clockwise and counterclockwise taping directions will use the reference of facing the front of the bar assembly. The direction in which taping happens is critical to limit the leading edges of the tape from rolling due to the friction of the acrobats' body movement direction in contact with the bar.*




*2. When taping, be sure to ensure that subsequent tape rounds cover over half of the previously taped path, with the rest covering the subsequent section of bar. Taping should be done this way, unless mentioned specifically.*

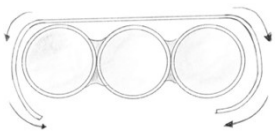
*3. As the hockey tape on each roll inevitably runs out, a new roll will be required to continue from where the previous roll left off. Preferably, the roll change should occur at the bottom surface of the bar. We advise that the new roll also cover a small portion of the old tape (about 2cm is sufficient) to prevent unraveling at the ends.*

**Step 17.** Ensure that the silicone caulking applied the day prior is cured. If applicable, flip the Russian bar assembly so the top is facing up (indicated as per the markings made on the Russian bar assembly ends).

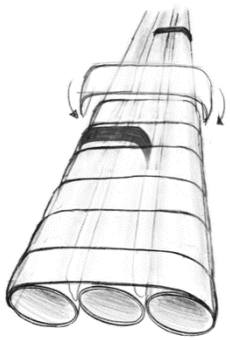
**Step 18.** With a lint-free cloth and window cleaner, wipe the pole surfaces to minimize buildup of dust, hair, and other debris.

**Step 19.** Using hockey tape, measure the length required to cover the circumference of the top, sides, and bottom of the Russian bar assembly with minimal excess tape. This length of hockey tape serves as a template. Using this template, prepare lengths of clear 2" echo tape (could be substituted with duct tape).

**Step 20.** Using the lengths of clear echo tape, begin taping the circumference of the bar surface by placing the middle the echo tape on the center of the top surface of the bar assembly, curling down the sides, and then around the bar at the bottom.



**Step 21.** One single layer of echo tape should now be applied along the length of the Russian bar, with the ends of each tape width flush with each other. Cover the length of the bar a second time with clear echo tape, this time from the center of the bar out to the ends. This step aims to create a flat and adherable surface for the installation of padding for the flyer and porter surfaces.



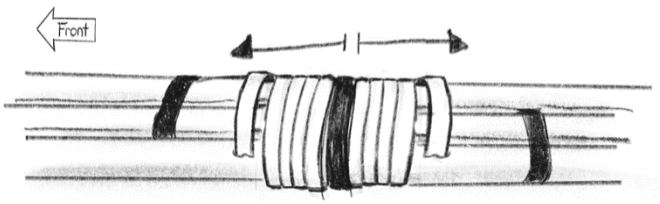
**Step 22.** Mark the geometric center of the length of the bar assembly with permanent marker. This center is half of the total length of the Russian bar assembly. Mark the full circumference of the bar assembly center.

**Step 23.** Label the front and back ends of the bar with a permanent marker. Identify the front end of the Russian bar by comparing the two sides to the center mark. The end that has more flexibility is the front of the Russian bar, while the less flexible end is the back.

**Step 24.** Measure and cut a 200cm length of 3/4" blue camping foam with a width sufficient to wrap around the sides of the bar. This foam will be used as padding for the jumping surface for the flyer in the center of the assembled Russian bar. The padding length can differ depending on the needs of the acrobats. A common length is 200 cm. Set the foam aside for assembly in the coming steps.

**Step 25.** Using two rolls of white 24mm hockey tape, begin taping the bar assembly from the center outwards with rounds of tape in a counterclockwise circular direction.

**Step 26.** The two rolls of hockey tape making rounds outwards from the center should be wound towards the ends of the bar in the same direction. Imagine a mirror dividing the bar assembly at the center, to visualize this process. The two tape rolls would radiate from the center as a mirror image of each other.



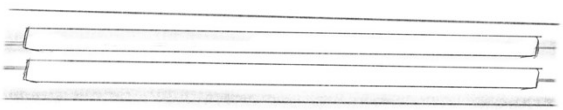

**Step 27.** Tape slowly and carefully, ensuring smooth adherence and a proper taping direction. Continue taping this way until the ends of the bar assembly.

**Step 28.** Place a single width of black 24mm hockey tape around the circumference of the center of the bar assembly, which will replace the marking of the center previously made.

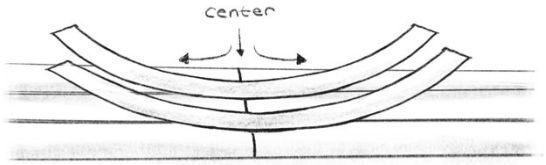
**Step 29.** Mark the center of the 200cm length of the blue camping foam previously cut. Align the camping foam's center marking to the center marking of the bar assembly. With the foam centered on the bar (both length and widthwise), use a permanent marker to mark the bar assembly where both ends of the camping foam are. These markings will serve as a template to adhere the center padding onto the Russian bar assembly with double-sided echo tape.

**Step 30.** Measure and cut two lengths of 2" wide double-sided echo tape. Use double-sided echo tape in this step is to adhere the camping foam padding to the bar assembly and create a stable surface in which the padding does not slip when the flyer uses the Russian bar.

**Step 31.** Place the two double-sided echo tape strands parallel to one another along the center length of the bar assembly where the padding will go. Align the widths of the tape with the ends of the flat surface of the bar assembly (i.e., before the sides curve down). The double-sided tape has two protective layers. Remove a small portion of the protective film on one side of the double-sided echo tape. Adhere this exposed sticky end at one end of the center padding markings made previously on the bar assembly.



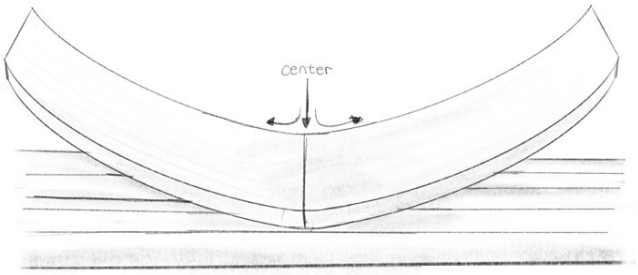
**Step 32.** Slowly adhere the exposed side of the tape to the bar surface along the length of the center padding location along the bar assembly. Maintain adequate tension on the tape by having another person pulling the tape taut. Peel off the protective film as you lay down the tape. Ensure that the top of the tape surface still has the protective film on.




**Step 33.** The center camping foam is now ready to be adhered to the Russian bar assembly with double-sided echo tape on the surface. Peel off the second layer of protective film on the top side of the double-sided echo tape.

**Step 34.** While two people pull the foam taught with moderate tension, align the center of the camping foam (both length and widthwise) to the center of the bar.

**Step 35.** Place the foam center on the bar and verify the correct alignment at the center of the bar assembly before pushing the center firmly onto the tape surface on top of the center of the bar assembly.

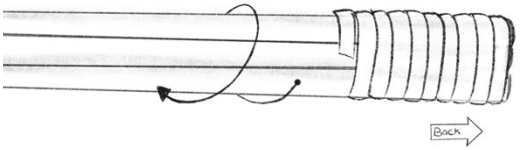



**Step 36.** From the center of the bar assembly working outward, slowly place the foam on the bar assembly while maintaining tension on both sides to ensure alignment on the bar until the foam is adhered.

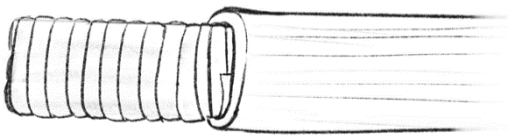
**Step 37.** The sides of the camping foam should hang off both sides of the bar assembly evenly on both sides, which will be wrapped around the bar with tape tightly in the following steps. Doing so will create a stable padded surface with defined side edges on the top of the Russian bar for the flyer to jump on.

**Step 38.** Mark the geometric center of the length of the bar assembly on the top of the center padding with one loop of black hockey tape.

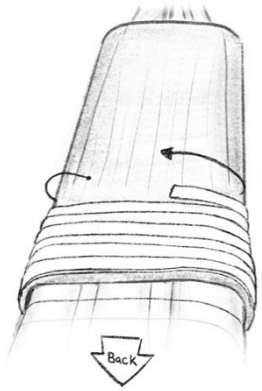
**Step 39.** Using two rolls of white hockey tape, tape the bar assembly starting from the ends of the Russian bar until the beginning of the center padding. Both ends should be taped from the end towards the center in a counterclockwise direction.



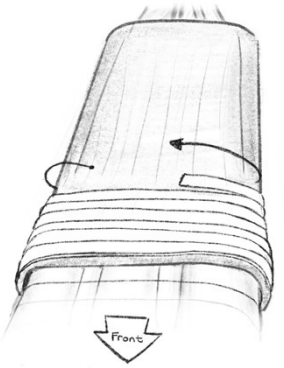

**Step 40.** Stop taping when the start of the center padding is reached.



**Step 41.** Using white hockey tape and beginning from the back end of the center padding, begin applying the tape towards the front end in a counterclockwise direction. Begin with two turns of tape such that they are flush with the edge of the foam surface and not on the portion of the unpadded bar assembly.

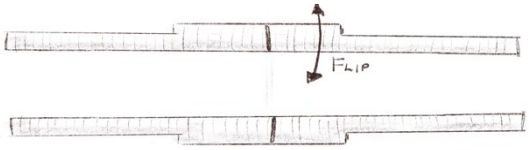



**Step 42.** Continue taping towards the front of the bar assembly, ensuring a moderate amount of tension while taping the center padding around the bar assembly. Make sure that the foam padding hanging off the sides of the bar assembly is tucked neatly around the contours of the bar assembly. Doing so will result in the center padding beginning to take on the contours of the round side of the bar assembly. Continue taping until the end of the foam padding at the front portion of the bar and finish with two turns of tape at the end.



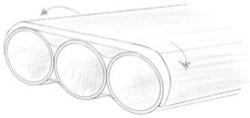

**Step 43.** The center padding can now be taped in a clockwise direction, from the front of the bar to the back. This second pass of white hockey tape on the center padding should be done with a stronger amount of tension when making rounds to further compress the center padding foam on the contours of the bar assembly. This tension is most important to be done on the side contours of the bar assembly, creating a stable and defined surface for the flyer to use.

**Step 44.** Flip the bar assembly such that the bottom surface is facing upward, to begin installing the protective foam for the porters' shoulders.



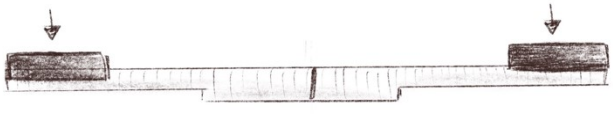

**Step 45.** Lay two parallel 50cm lengths of double-sided echo tape on both ends of the bar where the foam will be adhered, keeping the film (facing upwards) still on the tape. The process of laying the double-sided tape is similar the adhesion of the center padding.

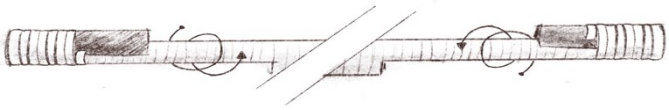
**Step 46.** Cut two 60cm lengths of 2" high-density gymnastics floor foam (also colloquially referred to as "truss-line") with a width such that a small portion of foam hangs off the sides of the bar.



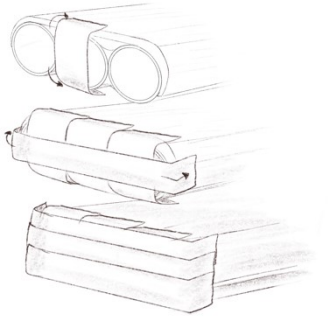
**Step 47.** Clean the surface of the foam that will be adhered to the bar assembly surface.

**Step 48.** Remove the second protective film of the double-sided tape and adhere the foam on both ends of the bar assembly so that the end of the foam is aligned with the end of the Russian bar assembly.





**Step 49.** Starting from each end of the ends align and tape the foam to the bar in a counterclockwise direction towards the center. Both porter padding areas will be wrapped in the same taping direction, with strong tension on the tape until the end of the foam. At the inside end of the porters' protective foam, use a stronger amount of tension. Advancing the tape forward slowly, creating a beveled interface along the transition of the foam to the non-padded portion of the Russian bar assembly.



**Step 50.** The ends of the Russian bar assembly will still show exposed ends of the poles. These exposed ends should be covered with hockey tape. First using three vertical strips of hockey tape beginning about one inch from the end of the bar, wrap around the end of the exposed pole diameters and end one inch on the other side.

**Step 51.** Repeat the same process of taping the exposed ends, but with lengths of tape horizontally until sufficiently covered.

**Step 52.** Repeat the taping pattern noted in step 49 to further compress the porters' end padding. Doing so will smooth out the padded bottom surface for the porter.

**Step 53.** With black hockey tape, add a loop of tape to demarcate the center of the Russian bar. Add a loop of black hockey tape to both ends of the center padding for the flyer. Both marks of black tape are useful for the flyer to coordinate where the padding ends and the center of the bar is located. The Russian bar is now fully constructed and ready for use.

## Russian Bar Training

The Russian bar is now fully assembled and ready to be tested for our study. Assuming that the bar is properly constructed and ready for use, the interviewed experts recommended various vital practices for effective and sustainable use. These considerations include the following categories: Facilities, storage, care, transporting, acrobats and their acrobatics figures, and coaching.

### Facility, storage, and care considerations

Discussed below are several noteworthy practices related to facilities, storage, and care considerations of the Russian bar.

#### *Humidity*

Humidity is observed to change the Russian bar's taped surface, particularly the adhesive properties of the tape surrounding the Russian bar. More specifically, an increase of humidity can make the hockey tape stickier on the surface. This increase in stickiness could pose a higher risk of friction injuries for the acrobats using the Russian bar (especially for porters). Conversely, an overly dry environment can result in the Russian bar surface being slippery and pose risks to both the flyer and porters.

***Temperature***

Activities involving use of the Russian bar should be done in a moderate temperature setting (i.e., standard room temperature). Cold temperatures have been noted to result in the Russian bar mechanical response being stiffer and less flexible, while hot temperatures have been known to result in the Russian bar being more flexible and forgiving.

***Surrounding cleanliness***

Maintaining a clean environment around the activities of the Russian bar is strongly recommended. We recommend avoiding storage and use of the Russian bar in an environment that is prone to dust, dirt, and debris (e.g., magnesium chalk, resin). Such contaminants can compromise the adhesive of the hockey tape surrounding the bar and create a slippery surface. Since the flyer is mounting on and off the Russian bar, keeping a clean surface around the Russian bar is recommended to avoid contaminants tracking onto the surface of where the flyer is jumping. Should the tape begin to form a slippery layer due to dust and debris, we recommend changing the tape layers as per the instructions mentioned previously.

***Russian bar care***

It is of primary importance to never drop the Russian bar on the floor. This order is increasingly crucial if the Russian bar is constructed with GFRP poles (e.g., UCS Spirit *fiberglass* poles). A bar exposed to forces that occur when dropped haphazardly can develop a compromised structural integrity, especially at vulnerable edges of the ends of the bar. Because of this, the ends of a Russian bar are more prone to breakage and experts recommend that those handling a Russian bar always make sure to place it on the ground delicately. When not in use, store the Russian bar away from any hazard and preferably covered. Make sure not to expose the Russian bar to extreme temperatures (either hot or cold). This can result in a compromised adhesive of the tape holding the poles together. In addition to protecting the Russian bar from abnormally low or elevated temperatures, ensure that it is not exposed to direct sunlight for extended periods of time. Exposure to sunlight can also impact the adhesives in the tape and could compromise its structural integrity as well. Thus, it best to limit exposing the Russian bar to unnecessary sunlight.

***"Breaking-in" a new Russian bar***

A newly constructed Russian bar should be "broken-in" for a few trainings. Much like a pair of new shoes, which will start off stiff and rigid, the Russian bar must relax to its "working" flexibility. The process of "breaking-in" is also analogous to the Russian bar, where a newly fabricated bar will start off stiff and loosen up as it is first worked in. Taking the time to break-in the new Russian bar also allows the acrobats to grow accustomed to the new bar. Interestingly, one could have the same construction process with near identical materials and their quantities, yet still be able to sense differences in the mechanical dynamics of the two different Russian bars. Thus, having adequate time to acclimatize to the potential changes in different Russian bars is essential. Training should be planned accordingly.

Interestingly, experts noted that at the beginning of each use of the apparatus, the Russian bar (along with the acrobats) must "wake up". What this anthropomorphism implies is that the Russian bar will also need to bend and flex, warming up the flexibility of the materials to increase the Russian bar's ability to be used for acrobatics.

***Storage and transporting***

We recommend storing the Russian bar in a tightly fitted case, lined with at least a 1" layer of medium-density foam around the internal surface including the ends to protect the bar when shipping or stored for extended periods. The foam-lined hard-shell exterior of the case should be made of a PVC tube with closures at the end, such that it covers, fits snugly, and protects the Russian bar from potentially damaging external elements while being transported or stored. This cover will also protect the Russian bar from dust and debris that can bind to the adhesives in the hockey tape and compromise its surface.

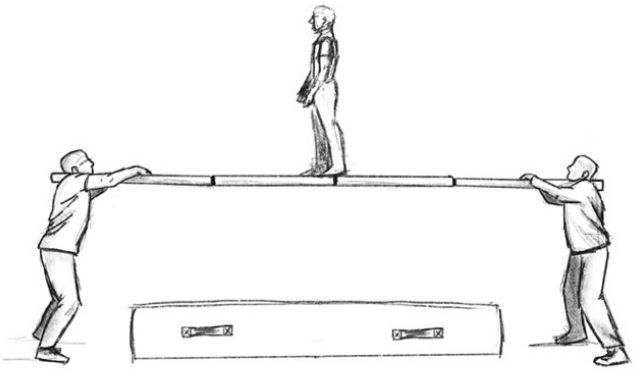
**Safety considerations**

Considering the Russian bar is noted to be a high-risk circus discipline, safety is of primary concern. Several noteworthy practices related to security measures and training facilities to safely learn and practice the Russian bar discipline exist. The following highlights some of the considerations discussed.

***Facility safety.*** Participants note that the space required to safely conduct acrobatic activities on this apparatus involves (at a minimum) an unobstructed floor-to-ceiling clearance of 7m, with at least 8m by 8m of smooth, nonslip surface to practice on. Preferably, the floor surface is covered in "*Marley" dance flooring*[12] to minimize risk of porters tripping or slipping.

***Safety measures.*** The recommended safety measures to implement are likely to vary depending on the experience and skill level of the Russian bar acrobats. It is crucial that activities be supervised by a skilled coach with considerable experience with this discipline.

Beginners should cover an approximate area of at least 7m by 5m with 2" high-density gymnastics roll ("truss line"). Standard sizes of these foam roll mats are 6 ft in width, so we recommended having three widths of foam roll mat aligned parallel to the Russian bar. In addition to the foam roll, we recommended placing a medium density 8" landing mat under where the flying acrobat is jumping on the Russian bar. Place the mat so it does not obstruct the porter acrobat's foot movements



[12] *Marley dance flooring:* https://www.stagestep.com/dance-floors/#dance-floors

when adjusting to catch the flying acrobat on the Russian bar.

Intermediate to advanced Russian bar acrobats could decide whether the previously discussed foam mat arrangement is helpful for them; however, it is still advisable to maintain at least some elements of protective foam padding around where the flyer is conducting their acrobatic maneuvers. This protective padding is often only present during training/rehearsal conditions. While minimal padding protects the flyer from the stage surface during Russian bar performances, using minimal or no surrounding protective padding is recommended solely for very experienced Russian bar acrobatic performers.

The overhead rigging arrangement should allow access to a two-point spotting belt ("lunge") during training/rehearsal seances. Using of a spotting belt with an experienced coach holding the lunge line is pivotal in learning the timing of the Russian bar, skill progressions, and developing skill mastery. The flyer's belt, which attaches to the lunge, should fit snugly on their hips. Should the flyer be doing twisting maneuvers that require spotting lunge assistance, they should have access to a lunge spotting belt that allows for twisting.

**Safety inspections.** It is recommended to remove the tape and inspect the bars in consistent intervals of either: 1) one year, 2) when a total of 300 shows and/or trainings have elapsed, 3) when the tape or foam padding requires replacing, or 4) when "creaking" or "cracking" sounds are heard from the Russian bar. The tape should be removed to inspect each pole, with a new pattern of tape applied following the inspection. The foam padding in the center and two ends must be removed and inspected for signs of foam density loss, perforations, and tears. Should the foam be compromised, it is vital to replace it entirely. While the foam is removed from the bar installation, the three poles should be inspected and cleaned of debris with window cleaner and a non-shedding utility cloth. If the silicone caulking is not in its proper place or is showing signs of degradation, the individual poles should be separated, and the old caulking removed and replaced. Clean the poles using an ammonia-based window cleaner and a lint-free cloth. To inspect the individual poles, use a bright light source to carefully check their surface for abnormalities. Such abnormalities often include cracks, splinters, dents, and fractures of the poles. Should there be any observed abnormalities, we strongly recommend replacing all three poles at once.

Experts discussed how they would often hear or feel an abnormality in the Russian bar before a failure of the poles. Should any abnormality be felt or heard, the poles will likely require replacing and should (at the very least) warrant a prompt inspection. Should a "creak" sound be present during use, or if the flyer feels like the Russian bar is jumping the flyer crooked (laterally), these are signs of structural fatigue or failure. All three poles should be replaced, even if only one pole shows signs of being compromised. Every expert interviewed in our study emphasized this last point as non-negotiable.

## Acrobats, coaches, and acrobatics

### *Acrobat considerations*

**Porters.** Porters could come from a variety of athletic disciplines and have varying morphologies. It is fundamentally important that each porter has sufficient strength and body control to withstand the load forces and adjustments to safely carry the flyer. A porter's height and weight can vary. Some porters are relatively tall and lean, while other porters can be relatively short and wideset. Porters working together should ideally be of a similar height to ensure that the Russian bar is parallel with the ground and thus a horizontally level surface for the flyer. However, some porters can differ in height. Such a situation would result in the taller porter having to squat deeper to accommodate the shorter porter and keep the Russian bar horizontally parallel with the ground.

**Flyers.** Regardless of their background, flyers of the Russian bar should have proficient abilities on the trampoline. Such skills can be considered a prerequisite for both body control and aerial awareness on the Russian bar.

Flyers tend to be petit in mass and size compared to their porters. In the spirit of moving away from discussions surrounding flyer weight, we emphasize the importance of the flyer's overall health and fitness level instead of arbitrarily noting weight recommendations and promoting unhealthy standards for this circus discipline. It is commonly noted that the strength of the flyer (and porters) is much more important than the weight of the flyer (and porters). Furthermore, some mention that a flyer can use their strength and precise timing to offset the load force that a larger flyer mass can exert on the porters.

### *Coach considerations*

An experienced coach who is well versed in the Russian bar discipline should always be present throughout the development of acrobats' training. Coaches are the front line of defense and are responsible for forming acrobats' technique and acrobatic skill on the apparatus. Coaches are also responsible for minimizing risks and maintaining a safe learning and training environment.

### *Interpersonal communication*

**Communication between porters, flyers, and coaches.** There is considerable importance in transparent, open communication channels between the trio and acrobatic coach leading their training. Flyers should feel comfortable sharing feedback to their porters, free of judgment and defense, and vice versa. Furthermore, the coach is responsible for fostering an open, communicative dialogue with the acrobats. This dialogue likely may include corrective suggestions, comments about the timing of the jumps, and what the group will do following that series. Importantly, every person involved (i.e., the flyer, porters, and coach) must know the series of maneuvers that the trio will perform. This communication should be confirmed before mounting the Russian bar. Doing so will allow the coach (who is likely holding the flyer in the spotting lunge) and porters taking care of the flyer to be aware of the maneuvers to expect and limit the opportunity for unplanned or unexpected movements.

Just as important as verbal communication is nonverbal communication, since this apparatus is discussed to be driven by performers' "feeling" and instinct—Relying on the postures, position, and sensations as input to adjust and conduct properly timed maneuvers. An important aspect of nonverbal communication is the balance a flyer and porters should feel before initiating a sequence. This balance is noted by all experts interviewed as the basis of properly initiating any acrobatic sequence on the Russian bar.

***Basics of technique***

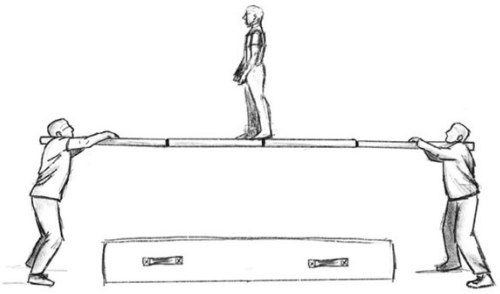
Several noteworthy practices are related to the basic technique of the Russian bar discipline. For this practical guide, we will discuss some basic drills and progressions recommended. Despite all efforts to understand basic Russian bar technique, we could not present a detailed depiction in this practical guide. As such, we recommend the FEDEC Russian bar guide by Stewart (2009) as a useful starting point for technique basics. Topics discussed include warming up, mounting onto the Russian bar, dismounting the Russian bar, and training recommendations (e.g., trampoline progression). Accordingly, this present practical guide will only span to the general drills as prerequisites before initiating training on the Russian bar.

The porter's primary focus is to search and maintain balance for the flyer laterally (i.e., side to side). The flyer's primary focus is to adjust medially (i.e., front and back). When they spot the Russian bar before their landing, they must their descent clear so that the porters can find the center of the flyer's hips to catch them safely on the narrow bar. Accordingly, many techniques and drills must be done to develop such competencies. Below are some discussed drills and basic techniques.

**Porter technique.** The porter's primary role is to place the bar underneath the flyer's feet, regardless of how they are landing. The porter's axis for adjustment is primarily lateral (e.g., side to side), and they must adjust the Russian bar to be in the center plane of the flyer.

***Porter posture and placement.*** The porter's positioning and stance is fundamentally important. The Russian bar should be situated on the porter's shoulder, specifically on their lower trapezius muscle, hugged in towards their neck and using their arms to stabilize the apparatus. Both porters should have the bar on the same shoulder (i.e., both right or left shoulders). There should be at least 10cm of Russian bar hanging off the back of the shoulder when at a neutral position (flyer standing still on top of the bar). This extra space behind the bar is important for the tendency of the Russian bar to slide forward on the porter's shoulders when the Russian bar bends due to the load the flyer is putting downwards on the bar. If there was not sufficient overhang and the bar slips forward too much, the end would fall off the frontal aspect of the porter's shoulder and could pose risk to the safety of the flyer and porter during their dynamic maneuver.

The porter's arms and hands will reach with an approximate 110° angle at their elbows and apply firm pressure with their hands and forearms crossing on top of one another to stabilize the Russian bar top. The firm actions of their arms and hands pushing down the bar when the flyer flexes the bar, and the firm pressure applied when the flyer is extended off the bar, maintain the stability of the push and increase the power of the maneuvers.



When holding the bar with the flyer standing still on the Russian bar, the porter's stance should be such that they are slightly leaned forward, with a slight bend in their knees. The porter's feet should be firm on ground, but with the weight primarily on the balls of their feet. The bar must be horizontally level with respect to the ground, which they can adjust with the bend in their knees. The posture for a porter is such that they should have tension in their posterior chain fascia and try to square their hips and ribs to be centered underneath the Russian bar. Doing so will allow them a solid frame to handle the load forces and maintain a stable position.

***Beginner porter drills.*** Porters must not only track the flyer and make lateral adjustments to position the bar underneath the center of their hips and catch their feet, but they also need to take inventory of the adjustments and position of the other porter. Porters should work together, in unison. Developing this instinct and collaboration will likely take time to develop properly. A useful drill for the novice porter to develop a sense of lateral adjustment and collaboration with their opposing porter involves placing the back two feet of a foldable chair on the bar and having the porters work together to balance it in the air without falling. Experts indicate that this drill helps develop the instincts necessary to be a porter.

**Flyer technique.** The flyer's primary focus should be on making their hips and shoulders square with feet in a clear spot for the porter to aim for and catch. A flyer should work dynamically with the Russian bar timing and push from the porters to do their maneuvers in the air, while trying avoid making lateral adjustments while in contact with the bar. Proper technique for a flyer takes time and experience to develop, but the following should give some context to consider when beginning Russian bar training.

***Flyer posture and placement.*** Foot placement is of primary concern for the flyer. Considering the Russian bar surface is only slightly wider than one single foot, the feet of the flyer must be staggered out for maximum stability. While depending on the comfort of acrobats, the flyer's dominant leg and foot (i.e., the leg that goes forward when stumbling forward) will likely be best in front. Stagger the feet such that the toes of each foot are turned approximately 20 degrees outward (i.e., outwards towards their hips) to cover the bar. The foot staggering should be such that there is approximately 5cm to 10cm of Russian bar length between the rear foot toes and the forward foot heel. This placement is thought to be the most stable for the flyer, allowing them the best base for their maneuvers on the Russian bar.

The flyer's body alignment is also fundamentally important. The flyer should maintain hips and shoulders that are square to each other and perpendicular to the length of the Russian bar. Given the staggered leg stance on the bar, maintaining even hip and shoulder balance can take some time to get used to. However, building this habit of proper alignment is exceedingly important. The flyer's head position should also be neutral. A novice might instinctually change their head

position while performing a skill to find the Russian bar for landing, but it is recommended to maintain a neutral head position with the flyer's eyes changing where they are looking.

***Beginner flyer drills.*** The flyer's primary focus should be on avoiding making adjustments and making their body visible for the porter to catch. Initially, this notion of the flyer not laterally adjusting seems unintuitive, and often, beginners have the instinct to try to balance themselves. Imagine a scenario where the flyer adjusts laterally when off balance on the Russian bar. Simultaneously, the porter also adjusts laterally to balance out the flyer onto the center of the bar. If the two of these occur to fix the same instability, the flyer will potentially be overcorrected and again in a state of imbalance. Thus, the flyer should refrain from trying to adjust laterally. Instead, flyers should focus more on maintaining square hips and shoulders, perpendicular to the Russian bar.

A useful drill for flyers to develop the instinct to not adjust or "search" laterally is to place the Russian bar across two foam gymnastics boxes. Instruct the flyer to step on the bar at one end and feel the bar's stability, side-to-side. The instinct to adjust can be calmed, by having the flyer find the spot where the less they search laterally, the less the Russian bar rocks laterally. Then, have the flyer walk across the bar with the same intent (i.e., not searching laterally). We recommend this drill for the first few months of learning the apparatus, until the instinct to laterally search has subsided.

***Beginning acrobatics.*** When the flyers and/or porters have mastered the beginning drills and their coach deems it appropriate, they can begin doing simple tempo jumps in the spotting lunge. The initiation of acrobatic maneuvers (e.g., tempo jumps, saltos) is beyond the scope of this practical guide. Accordingly, we recommend the FEDEC guide by Stewart (2009) as an effective resource for a further discussion regarding beginning acrobatics on the Russian bar.

### *Risk and injury considerations*

Considering that the Russian bar apparatus is a risky circus discipline, careful consideration about the risks and injuries should be made and are briefly discussed below.

**Porter injuries.** Porters discussed sustaining chronic and transient injuries (i.e., wear and tear injuries) to their neck, back, ribs, and shoulders. Furthermore, considering that porters hold the Russian bar on one of their shoulders and that shoulder is exposed to a considerable load force when using the bar, porters could develop asymmetric strength, compensations, and injuries on one side of their body. Additionally, jaw injuries are noted to occur, cited to be when the porter does not hold the bar enough or when the flyer does not land on the center padding.

In addition to orthopedic injuries, skin injuries can occur due to friction of the hockey tape abrading where it is in contact with the porter's body. Such friction can often result in shoulder, neck, and forearm blisters. If not properly treated, these injuries can be prone to bleeding and infection from exposure to pathogens in the open wounds. Some note that they often use soft towels between the bar and their body, which can relieve some of the friction. Eventually, these areas of concern prone to friction could develop into calloused skin and potentially less prone to abrasions from using the Russian bar.

**Flyer injuries.** In addition to chronic and transient injuries, flyers are also more prone to acute, blunt trauma injuries resulting from: a) Failing to land on the Russian bar surface safely or b) crashing to the ground when not caught by the bar properly upon landing. Areas of concern for flyers include foot injuries (e.g., heel bruises, toe dislocation), lower leg injuries (e.g., Achilles tendons, shins, ankles), and head and neck injuries from traumatic impact to the ground (e.g., concussions).

**Risk considerations.** Despite the risks, with the proper accouterments for the acrobats, there is a high likelihood that they can adequately learn the Russian bar discipline with sufficient time and support from experienced coaches. When learning the Russian bar, it is recommended that there be at least skilled acrobat in the trio (ideally, two). This allows those with experience on the Russian bar to lead the development of proper timing and communication, developing the inexperienced acrobat and offering insight that could be useful for their learning process. Such a practice also allows the experienced acrobats to ensure that this apparatus' risks and hazards are minimized and managed.

## Discussion and Reflections

Our present study had two primary motives. The first motive sought to document a current snapshot of the favorable North American practices of the Russian bar apparatus, developed by route of problem-centered interview method posited by Döringer (2020), and create a focus group with experts regarding effective practices of constructing a Russian bar. Second, we sought to examine Russian bars used by various organizations in Québec via mechanical static flexion tests to explore the mechanical properties and the different Russian bars constructed.

### Static flexion test result interpretation and discussion

The values of the flexion tests provide an interval of elasticity of bars used in North America, specifically in the geographic region of Quebec (where all Russian bars in this study were tested). The relation between the performance and interval of elasticity of these Russian bars would need to be studied further to determine a plausible association between these variables. Furthermore, consider the extensive paucity of accessible information on the Russian bars that underwent the static flexion tests provided by the various affiliated organizations. This missing information was such that we could not determine the potential impact that pole diameter and materials used could have had on the static flexion of the Russian bars.

Based on observations of other organizations Russian bars, some seem to have been made in a similar method. First, 7D(7) and 7D(8) appear to be constructed similarly. CDS(3) and CDS(5) also appear to be constructed similarly. This similarity in construction is reflected in the values of the slopes (denoting elasticity, in m/kg) for two pairs of bars. 7D(7) and 7D(8) have a slope of 0.002317 m/kg and 0.002235 m/kg, respectively (a difference of 3%). CDS(3) and CDS(5) have a slope of 0.002635 m/kg and 0.002678 m/kg, respectively (a difference of 2%). The small deviations for these two pairs of bars allow us to suggest that the two pairs are likely manufactured similarly.

We expected the new bar ENC(10new) to be more rigid than when the same Russian bar ENC(10) was tested, however this is not what we measured. In addition, we did not expect to observe a difference in elasticity between ENC(1) and ENC(10). To attest to this expectation, most Russian bar acrobats note that they feel that the properties of the Russian bars change very little over time. We used the same manufacturer of poles to build the new Russian bar during the focus group as with ENC(1). Therefore, we expected to find similar flexion properties between the two bars. Interestingly, this similarity in elasticity was not the case in our study. ENC(1) was softer when compared to ENC(10). Unfortunately, no clear explanation of this phenomenon can be determined. One such possibility could be that the way Russian bars ENC(1) and ENC(10) were made lacks similarity. Considering that we could not obtain documentation on how ENC(1) was manufactured, it is possible that the placement of the poles, the silicone caulking used, or the adhesive tape used and taping technique have a sizeable influence on the elasticity properties. There is also a possibility that the supplier of the poles has changed their manufacturing technique, thus creating a difference in pole properties – despite being made by the same manufacturer.

A study conducted by Warburton (2015) measured the deflection of 16 pole vaulting poles. Under the action of a 50lb mass fixed in its center and supports set at 30cm from the ends, a 5m long pole (fiberglass, weight rating 190/86) had a deflection of 17.9cm, while another 4.9 m long bar (fiberglass, weight rating 200/91) had a deflection of 15.8cm. In our study, the Russian bars were between 4.9m to 5.0m. The notable exception were with Russian bars 6, 7, and 8. We found that these Russian bars had a measured deflection between 5.5cm and 7.2cm. Considering that the Russian bar consists of three poles and thus can be simplified as a summation of three poles, our results are reasonably consistent with the study of Warburton (2015) according to the models (5.5cm * 3 = 16.5cm, a difference of 4% compared to that of Warburton, and 7.2cm x 3 = 21.6cm, a difference of 20% compared to that of Warburton). Russian bars 6, 7, and 8 had a length of approximately 4.3m. The poles in Warburton's study measured a deflection ranging from 19.5cm as a minimum (carbon fiber composition, weight rating 155/70) to a maximum of 21.4cm (fiberglass, weight rating 145/66) with 4.3m long bars. In our study, 4.3m long bars had a deflection between 4.5cm and 6.3cm. Such results are reasonably consistent with Warburton's study (4.5cm * 3 = 13.5cm, a difference of 30%, and 6.3cm * 3 = 18.9cm, a difference of 3%). Many factors could explain these differences between our study and Warburton's. Firstly, we do not know the exact patterns of how the bars are treated in either our study or the Warburton's study. Additionally, the practice of adding silicone and various adhesive tapes on the poles around the Russian bars could likely result in an effect that reduces the flexibility (i.e., becomes stiffer).

For the static flexion tests, we measured a few points for each Russian bar and did not repeat the measurements for most datapoints. Furthermore, testing protocols vary slightly by location and the available resources at that facility. Uncertainties in measurement are expected and need to be considered in the interpretation of the results. Furthermore, although a linear trend has been proposed, we cannot assume whether the Russian bars continue to behave in a linear trend with higher masses. Furthermore, while we carried out tests in a static state, acrobatic performances

put the bar in a dynamic state. Thus, these static flexion tests conducted in our study may not directly reflect the Russian bar's mechanical behavior during dynamic use with acrobats. Therefore, we recommend that when characterizing a Russian bar in future studies, to make careful considerations about effectively conducting tests in conditions like those encountered in circus performance.

**Limitations and recommendations**

The practical guide proposed is preliminary and should be considered only partial. This is partly due to the limited number and scope of problem-centered interviews conducted for this study. The opinions and practices discussed in the practical guide are not grounded in a theoretical framework, per se. Nor is our practical guide rooted in established published literature on the subject, since there is none documented (to our knowledge). Aligned with our aims, we sought to document the current North American best practices and opinions from experienced professionals accustomed to the Russian bar circus apparatus. The sample of participants interviewed is limited in scope and location and does not encapsulate all tiers of involvement in the Russian bar circus discipline. A notable absence of rigger perspectives was present in our interviews. Only one rigger was available to participate in this study, against all efforts to include more riggers. Accordingly, the practices and opinions discussed should be interpreted with caution. Furthermore, although not explicitly mentioned in this practical guide to summarize the bottom-line considerations, they do not represent a scientifically rigorous, statistically tested depiction of the practices of the Russian bar circus apparatus.

Inherent with our study, we note the presence of limitations in this practical guide and method design. Primarily, the limitations concerning the nondirective interviews with experts were that we could only discuss what was relevant without a theoretical framework to base our interviews around. As such, the accounts are preliminary and cannot be considered an exhaustive account of knowledge of this apparatus. There were clearly many discussions that could have happened beyond the scope of the interviews in this study. Such discussions could be centered around acrobatic techniques of the Russian bar, technical progressions, and effective timing of actions (of both porters and flyer) on the Russian bar.

Finally, as discussed in the static flexion test results, the lack of information that could be obtained regarding the Russian bars tested posed a large issue. We could not assign reasonable interpretations of the potential impact various materials and specifications have on the deflection (i.e., elastic properties) of the Russian bar. One such recommendation we have in response to this encountered issue is to encourage diligent documentation of both the materials used and the construction and maintenance process of this circus apparatus. Such practice could allow researchers to interpret research findings more effectively, which could benefit those involved in the Russian bar discipline and the circus community more broadly.

Considering the abovementioned limitations, we recommend empirical documentation and further research on the Russian bar circus discipline. This additional call to research is specifically targeted to document and develop our understanding of this circus discipline which, to our knowledge, has little to no scientific research documented.

**Acknowledgements**

We would like to acknowledge the contributions of Cirque du soleil, Machine de cirque, 7 Fingers, École nationale de cirque, and Barcode. We would also like to thank all participants that voluntarily took part in our study. Finally, special thanks to our talented illustrator Haley Tenn, who is also a student at ÉNC.

# Appendix A

## Photographs of the Russian bars for the static flexion tests

**Figure 6**

*Russian bars tested from ÉNC (from left to right): ENC(1), and ENC(10new)*

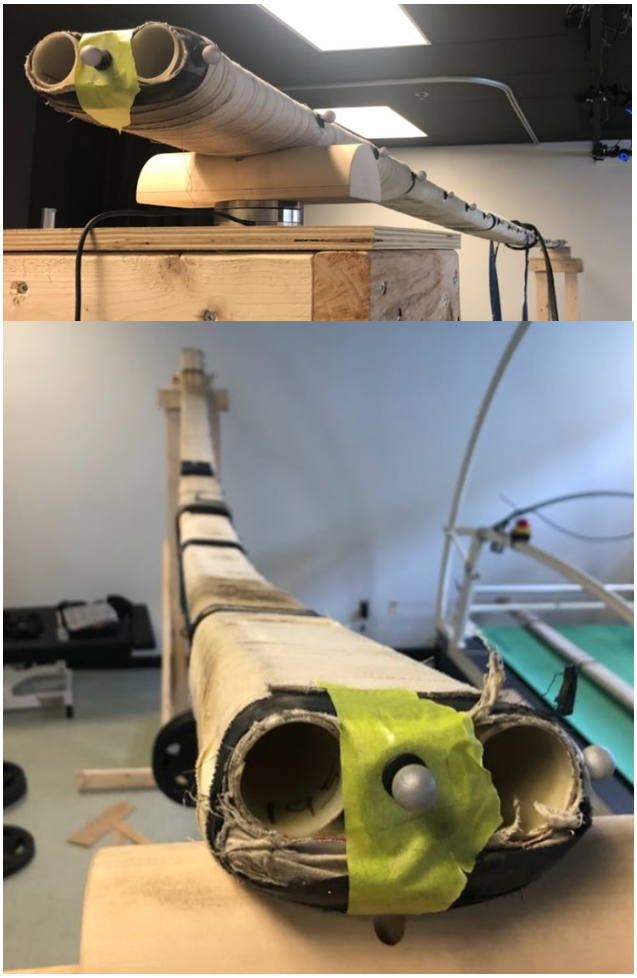
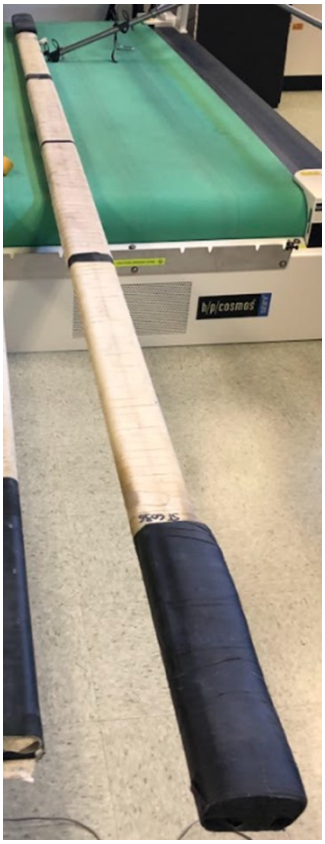


**Figure 7**

*Russian bars tested from CDS (From left to right): CDS(3), CDS(4), and CDS(5)*



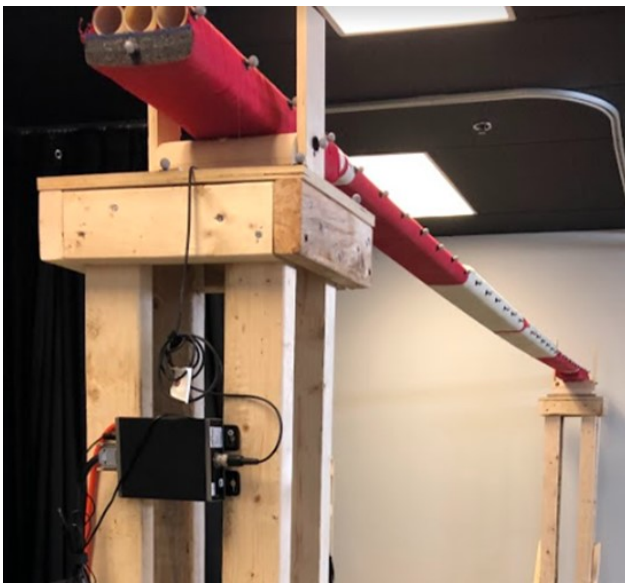



**Figure 7**

*Russian bar from MDC: MDC(6)*

**Figure 8**

*Russian bars tested from 7F (from left to right): 7F(7), 7F( 8), and 7F(9)*

# Appendix B

## Static flexion test protocols

**Figure 9**

*Test protocol at INEDI for the Russian bars 1, 2, 3, 4, and 5*

The flexion force was applied with gym training weights. The bend (flexion) of the Russian bar was recorded with motion capture via the white markers along the bar. Pressure forces were measured with load cells at each support on the ends of the Russian bar.

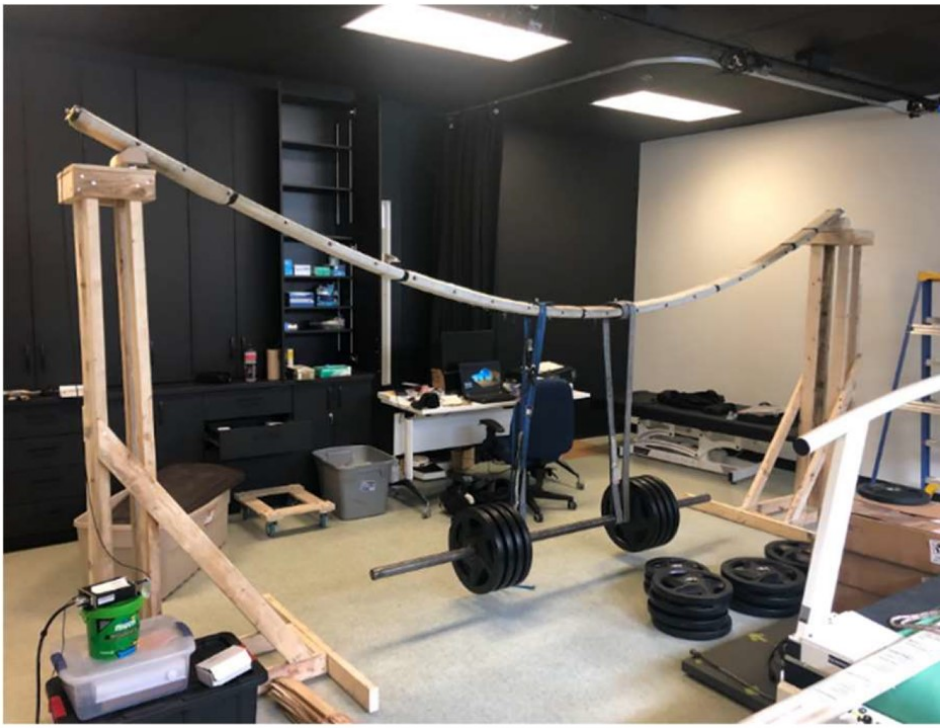


**Figure 10**

*Test protocol at MDC for Russian bar 6*

The flexion force was applied by the weight of human beings. The bend (deflexion) of the Russian bar was recorded with motion capture via the white markers along the bar. Pressure forces were measured with load cells at each support on the ends of the Russian bar.

**Figure 11**

*Test protocol at 7F for the Russian bars 7, 8, and 9*

The flexion force was applied with an anchor point fixed to the ground and measured with a dynamometer. The Russian bar bend (deflection) was measured using a flexible measuring tape.

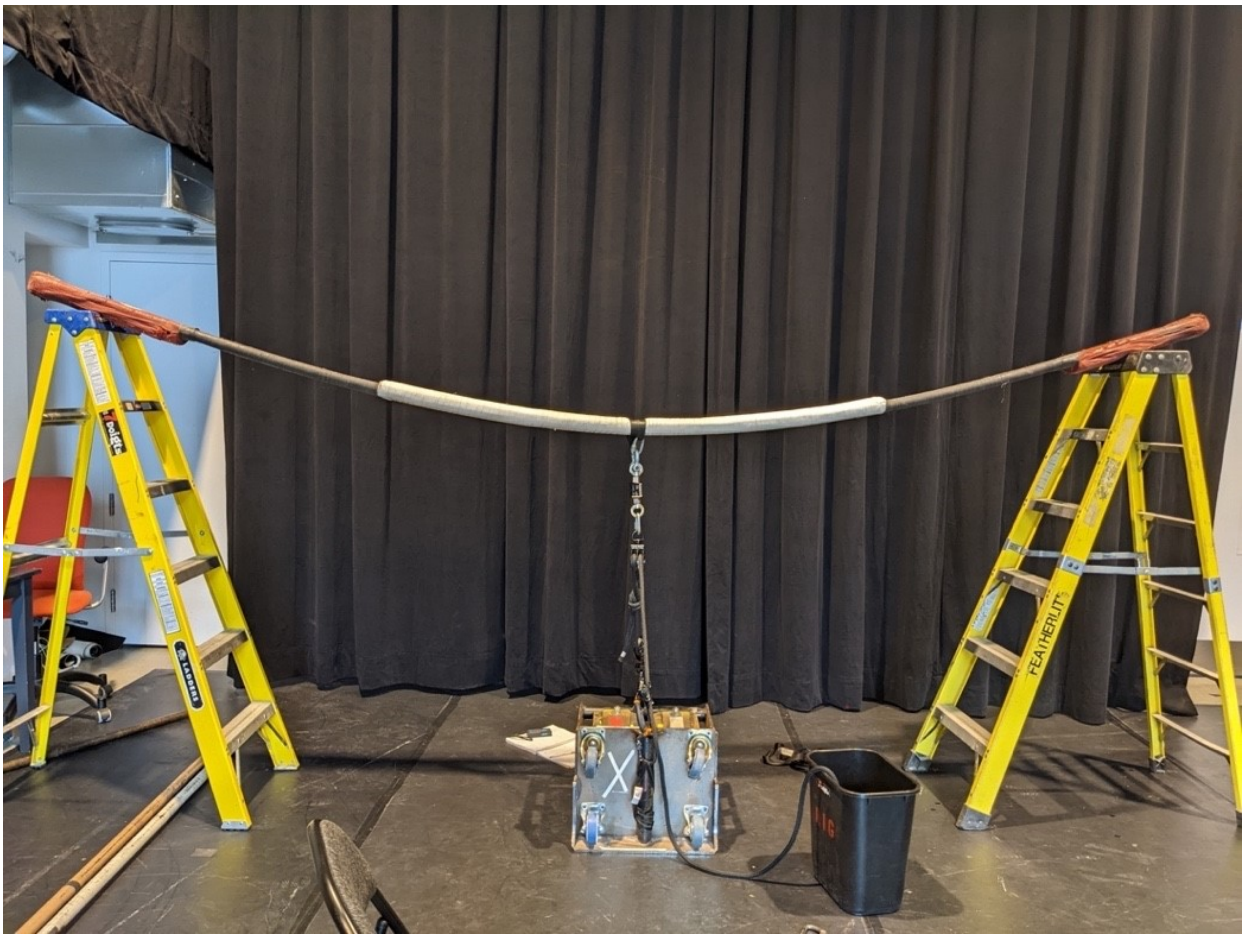
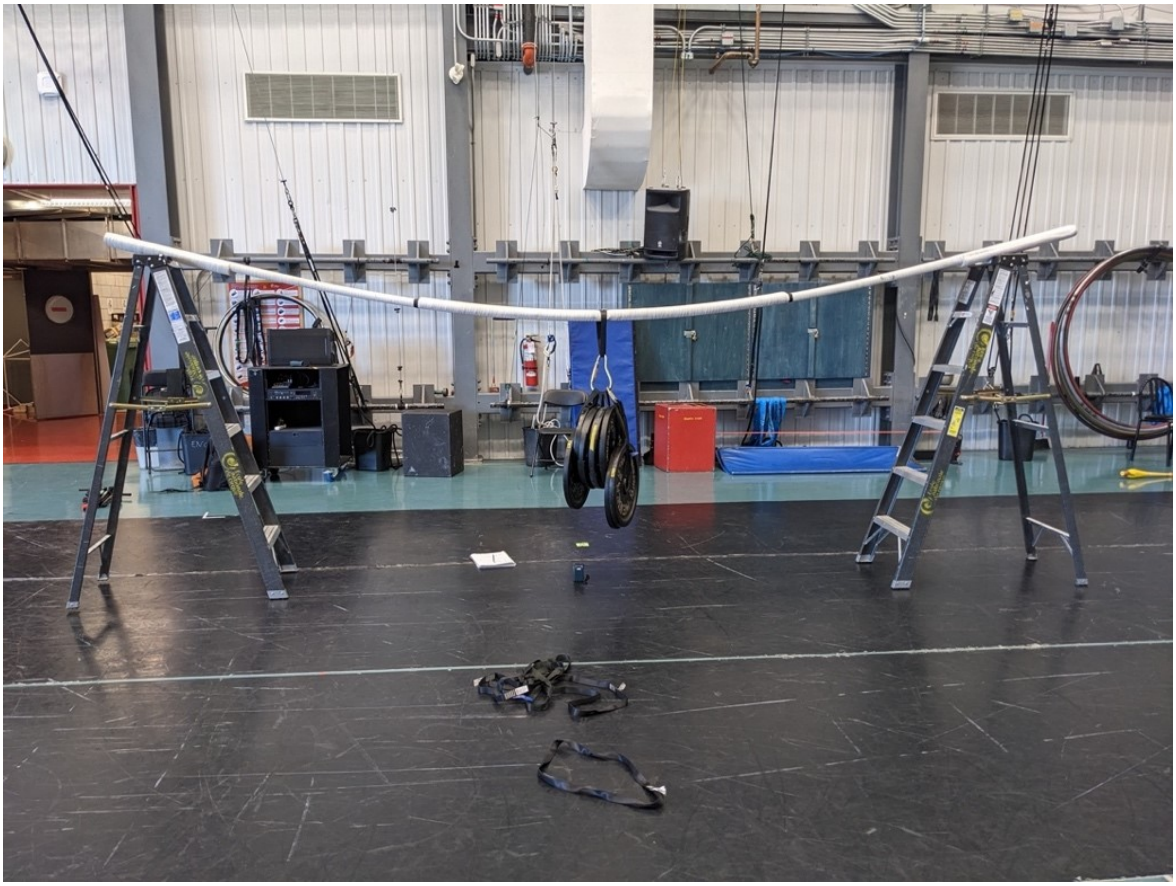


**Figure 12**

*Test protocol at ÉNC for Russian bar 10*

The flexion force was applied with gym training weights. The bend (deflection) was measured with a flexible measuring tape.



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